PB83-180422

Development Document for Final Effluent Limitations Guidelines, New Source Performance Standards, and Pretreatment Standards for the Coal Mining Point Source Category

(U.S.) Environmental Protection Agency
Washington, DC

Oct 82

U.S. Department of Commerce
National Technical Information Service
NTIS

PB83-180422

United States
Environmental Protection
Agency

Effluent Guidelines Division
WH-552
Washington DC 20460

EPA 440/1-82/057
October 1982

Water and Waste Management

EPA

Development Document for Effluent Limitations Guidelines and Standards for the Coal Mining

Final

Point Source Category

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA 440/1-82/057	2.	3. RECIPIENT'S ACCESSION NO. PB83 180422
4. TITLE AND SUBTITLE Development Document for Effluent Limitations Guidelines & Standards for the Coal Mining Point Source Category - Final		5. REPORT DATE Oct 1982
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Weideman, Allison		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Environmental Protection Agency Effluent Guidelines Division WH-552 401 M Street, SW Washington, DC 20460		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS US Environmental Protection Agency 401 M Street, SW Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

The primary purpose of this study was to determine the presence and concentrations

16. ABSTRACT

The primary purpose of this study was to determine the presence and concentrations of the 129 toxic or "priority" pollutanrs in the coal mining point source category for possible regulation. This development document presents the technical data base developed by EPA with regard to these pollutants and their treatability for regulation under the Clean Water Act. The concentrations of conventional and non-conventional pollutant control technology (BCT) and the best available technology economically achievable (BAT), respectively. Necessary modifications to prior regulations based on best practivable control technology currently available (BPT) were also identified. Treatment technologies were also for designation as the best available demonstrated technology upon which new source performance standards (NSPS) are based. This document outlines the technology options considered and the rationale for selecting each technology level. These technology levels are the basis for the promulgated effluent limitations.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (9-73)

DEVELOPMENT DOCUMENT
FOR FINAL
EFFLUENT LIMITATIONS GUIDELINES
NEW SOURCE PERFORMANCE STANDARDS,
AND
PRETREATMENT STANDARDS
FOR THE
COAL MINING
POINT SOURCE CATEGORY

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September 1982

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SECTION I

SUMMARY

The primary purpose of this study was to determine the presence and concentrations of the 129 toxic or "priority" pollutants in the coal mining point source category for possible regulation. This development document presents the technical data base developed by EPA with regard to these pollutants and their treatability for regulation under the Clean Water Act. The concentrations of conventional and nonconventional pollutants were also examined for the establishment of effluent limitations guidelines based on the application of the best conventional pollutant control technology (BCT) and the best available technology economically achievable (BAT), respectively. Necessary modifications to prior regulations based on best practicable control technology currently available (BPT) were also identified. Treatment technologies were also assessed for designation as the best available demonstrated technology upon which new source performance standards (NSPS) are based. This document outlines the technology options considered and the rationale for selecting each technology level. These technology levels are the basis for the promulgated effluent limitations.

A second purpose of this study was to assess the need for establishing effluent limitations to regulate discharges from surface and deep (underground) mines after cessation of active mining. The wastewaters from these facilities where coal extraction has ceased are referred to as "post-mining discharges."

A third purpose was to assess the appropriateness of establishing a separate subcategory for regulation of discharges from coal mines in the western United States. And finally, a fourth purpose was to review existing effluent limitations during precipitation events.

SUBCATEGORIZATION

On 26 April 1977, the Agency promulgated BPT effluent limitations for three subcategories in the coal mining point source category. These subcategories include acid drainage mines, alkaline drainage mines, and preparation plants and associated areas. On 12 January 1979, the Agency published new source performance standards for these three subcategories. Two additional subcategories (areas under reclamation and western mines) were also established at that time.

After an extensive statistical and engineering analysis of category profile factors, the existing BPT and NSPS subcategorization is being modified in this rulemaking to include a number of revisions. First, post mining discharges are established as a subcategory for regulation of effluents from surface and deep mines. For surface mines, areas where coal extraction and recontouring have been completed and revegetation has been commenced will be subject to settleable solids and pH limitations. For deep mines, any discharge to surface waters after completion of active mining operations is subject to identical limitations as those in effect during active mining. The effluent limitations guidelines in the post-mining subcategory will apply until the release of the reclamation bond required under the Surface Mining Control and Reclamation Act ("SMRCA").

Second, the Agency has compiled and reviewed data from a number of programs investigating sedimentation pond performance during various rainfall events. Control of settleable solids and pH during rainfall periods will be required. These limitations will apply for increases in overflows resulting from rainfall events (or snowmelts of equivalent volumes) less than or equal to the 10-year, 24-hour storm. If a larger event occurs, operators will be required to comply with a pH limitation. Facilities will not be required to have a pond which can contain the runoff from a 10-year, 24-hour storm in order to qualify for the alternate limitations (as was in the previous regulations and the proposal for this rulemaking). Rather, facilities are eligible for these alternate limitations irregardless of the type of treatment facility.

Third, the Agency has concluded that discharges from western mines do not warrant separate subcategorization. The BAT subcategorization will be identical to the modified BPT categorization, since no additional factors were identified that substantially affect effluent characteristics. New source subcategorization is also identical to the modified BPT subcategorization scheme with the exception of the preparation plant and preparation plant associated area subcategory, which is subdivided into the two component segments: preparation plants and preparation plant associated areas. NSPS for coal preparation plants is set at zero discharge; NSPS for associated areas is equal to the modified BPT. The modified storm exemption will generally apply to all subcategories. However, no exemption will be available for discharges from new source preparation plants or underground workings at underground coal mines except if they are commingled with surface runoff. Rainfall will not substantially affect underground mine discharges, and relief from limitations during storm events is not necessary. Also, the zero discharge requirement is being established for new source preparation plants, and thus no storm exemption is available for discharges from this new source subcategory.

WATER SOURCES

The major sources of wastewater in the coal mining category include precipitation, surface runoff, ground water infiltration, and effluents from coal preparation plants. No process water is used in the mining phase, except for minor consumption in dust suppression, pump coolants, and firefighting needs. Therefore, pollution abatement in this industry must be approached differently than other industries, with reliance on operating and management practices for wastewater source control as well as end-of-pipe treatment technologies. In the preparation phase, water is used to clean the raw coal. Water usage is typically 350 gallons per ton and is laden with coal and refuse fines which must be removed prior to discharge or reuse.

POLLUTANT COVERAGE

Toxic (Priority) Pollutants

Sampling and analysis for the 129 priority pollutants was conducted in this industry. Sixty-seven of the 114 toxic organics were not detected in treated mine wastewaters and 23 were detected in the effluent of only one or two mines and always below 10 ug/l. This level is considered to be the effective detectability limit for state-of-the-art analytical techniques. Ten of the toxic organic pollutants that were detected above 10 ug/l are believed to be present due to sampling, preservation, or analytical contamination. The remaining 14 were present in amounts too small to be effectively reduced by additional treatment technology. Thus, no regulations are established for the toxic organic compounds. Five of the thirteen priority metals (antimony, beryllium, cadmium, silver, and thallium) were found in treated wastewaters at levels near or at their limits of detection by state-of-the-art analytical techniques. Therefore, no limitations are established for these pollutants. The remaining eight toxic metal pollutants (arsenic, chromium, copper, lead, mercury, nickel, selenium, and zinc) were found at levels above their detection limits but not uniformly throughout the industry. As discussed in Section VI, these metals are already effectively controlled by BPT technology, i.e., by treatment measures already in place. Cyanide was found only in isolated cases and always at levels well below 10 ug/l. This concentration is well below treatability levels for quantifiable reduction of cyanide, and thus no limitation is established for this pollutant.

Chrysotile asbestos is the form of asbestos the Agency believes is the most important type to consider for regulation. This form was found in coal mining wastewaters at concentrations considered to be slightly above background levels, and thus no limitation is established. The Agency is expanding the asbestos data base and refining the analytical protocol for asbestos analyses. Further, toxicological studies are being conducted to determine the environmental effects of other forms of asbestos. Pending results from these programs, the Agency will assess the need for establishment of an effluent limitation for other asbestos forms.

Conventional Pollutants

The Agency is reserving the promulgation of effluent limitations for conventional pollutants pending finalization of the cost methodology for removal of these pollutants. New source performance standards, however, for TSS and pH are being promulgated, and BPT limitations for these parameters remain in effect.

Nonconventional Pollutants

Iron and manganese are the only two nonconventional pollutants requiring control. These are effectively reduced by application of BPT. Therefore, the Agency is promulgating BAT limitations for iron and manganese equivalent to the BPT levels.

TREATMENT AND CONTROL TECHNOLOGY

Amendments to BPT

No effluent limitations guidelines previously promulgated for the three BPT subcategories will be modified under this rulemaking except as outlined below.

Post Mining Discharges

Surface Mines. The Agency instituted a self-monitoring program involving 12 mine companies (23 sites) to establish performance data for sedimentation ponds receiving drainage primarily from areas under reclamation. Results indicate that settleable solids and pH are consistently reduced by properly designed, constructed, and maintained ponds or basins. Thus, the Agency is promulgating limitations for these parameters for this subdivision. These effluent standards will apply from the time any acreage is first revegetated after active mining through release of the applicable SMRCA reclamation bond for that acreage.

Underground Mines. Technology installed for treatment of raw drainage during active mining is the basis for regulation of underground mine drainage after active mining ceases. For acid underground mines, this will include neutralization and settling; settling alone is the appropriate technology for alkaline underground mines. Costs for operation of this equipment will be similar to annual costs during the active mine life.

Alternate Limitations During Storms

Previous studies conducted by EPA have shown that the TSS limitations cannot be consistently met during precipitation events due primarily to site specific factors. Accordingly, previous coal mining regulations have afforded relief from effluent requirements during storm conditions provided the treatment facility is properly designed and operated. The exemption permitted a discharge without regard to effluent quality.

Since promulgation of the previous BPT and NSPS coal mining regulations, two separate studies (one at 24 sites, the other at 8 sites) have been performed to evaluate the performance of sedimentation ponds during various rainfall events. These studies concluded that settleable solids and pH best characterize pond performance, and limitations are established for these parameters. Compliance with the limitations will be required for any discharges due to precipitation except those caused by storms greater than a 10-year, 24-hour precipitation event. For these events, only a pH limitation will apply. These are the modifications to the exemption published in 44 FR 76788 (28 December 1979). The additional costs incurred for this modification will be confined to a minor amount of additional, inexpensive monitoring and some potential supplemental lime addition requirements. These are judged to be relatively minor, and far outweighed by the potential savings accrued from the elimination of the 10-year, 24-hour design standard. No alternate limitations or exemptions are provided for discharges from the underground workings of underground mines except where such discharges are commingled with surface runoff. In order to allow alternate treatment systems and to be consistent with the proposed Office of Surface Mining (OSM) regulations, the Agency has also decided to delete pond design criteria as requirements for eligibility for the storm exemption. Thus, facilities will not have to construct specified treatment ponds; they will instead be required to meet effluent limitations.

Western Mines

EPA evaluated wastewater characteristics and treatment technologies used by eastern and western mines to determine if differences exist in pertinent effluent characteristics between eastern and western mines. EPA determined that, while treatment systems at western mines discharge less frequently than those at eastern mines (due primarily to less precipitation and generally larger design volumes), effluent quality of western mine treatment systems is virtually the same as that for eastern mines. Thus, a separate "western mines" subcategory is not appropriate for BAT and NSPS regulations for the coal mining industry. It should be noted, however, that at 40 CFR Part 122.62(1)(2) (45 FR 33450) and 40 CFR Part 123.7 (45 FR 33469), existing NPDES permit limitations which are more stringent than subsequently promulgated guidelines may be retained upon reissuance of the permit. Moreover, regional permit authorities have the freedom to impose more stringent requirements in light of site specific conditions (see 45 FR 33290, 19 May 1980).

BAT

Acid Drainage Mines

The Agency conducted sampling at 18 acid drainage mine sites and evaluated discharge monitoring reports (DMRs) submitted under the National Pollutant Discharge Elimination System (NPDES) for 56 additional facilities in this subcategory. Results indicate that treatment technology already installed, including neutralization, aeration, and settling, effects substantial reductions of the key pollutant parameters, including TSS, iron, manganese, and the toxic metals. Further, substantial reductions by additional treatment technologies, including flocculant addition and granular media filtration, were not achieved, according to treatability studies conducted by the Agency on wastewaters from a number of coal mines. Therefore, the BAT effluent limitations are based upon BPT technology and are identical to the BPT effluent limitations.

Alkaline Drainage Mines

The Agency sampled effluents from 28 different facilities and evaluated DMRs from an additional 32 coal mines in this subcategory. These effluents contain very low concentrations of toxic and nonconventional pollutants after application of settling, which is the treatment option upon which BPT limitations were promulgated. The Agency has thus concluded that BAT limitations should be equal to BPT effluent limitations.

Preparation Plants and Associated Areas

The Agency conducted a sampling program at 28 preparation plants during the BAT review. Further, an industry survey of wastewater treatment practices was instituted. One hundred and fifty-two plants responded to this survey. Discharge data were also collected from DMRs for an additional 12 sites. Although raw wastewater from this subcategory can contain very substantial amounts of TSS and metals, they are significantly reduced by BPT-level technology, i.e., settling technology, with neutralization also necessary for acidic associated area drainage. Treated waters are often at least partially reused.

A number of end-of- pipe treatment technologies and a zero discharge requirement were investigated for application in this subcategory. Where preparation plant wastewater can be segregated from associated area wastewater, zero discharge (or total recycle) of water can be achieved. Because it is currently common practice in the industry to combine these wastewaters for treatment, most operators would have to retrofit separate treatment systems for the two wastewaters. This involves substantial capital and annual expenditures. In contrast, these retrofit costs are not incurred for new facilities.

Consequently, the Agency has established a zero discharge requirement for new source preparation plants while not applying such a requirement for existing sources. Discharges from existing sources were evaluated to determine the merits of additional treatment downstream of the existing BPT treatment system. The two technologies investigated were flocculant addition and granular media filtration. Results indicate that neither of these achieved significant pollutant reduction beyond BPT. Therefore, BAT limitations will be identical to BPT limitations for this subcategory.

Amendments to NSPS

New source performance standards were promulgated by the Agency on January 12, 1979 (44 FR 2586). With the following exceptions, this regulation does not change these standards. The previous regulation set NSPS equal to BPT.[1] The new regulation, however sets NSPS for coal preparation plants at no discharge of wastewater pollutants. This is the best available demonstrated technology, having been installed in a number of preparation plants in regions of varying topography and climate. Associated area drainage will be neutralized and settled independently of the preparation plant water circuit, for compliance with limitations equal to those established for BPT.

The zero discharge standard for preparation plants includes a provision for an occasional purge or release of process wastewater when necessary to reduce the concentration of solids or process chemicals in the water circuit to a level which would not interfere with the preparation process or process equipment.

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[1] NSPS were based on BPT technology. However, the numerical iron limitation of 3.0 mg/l 30 day average, 6.0 mg/l daily maximum was set for NSPS, based on evaluation of the data collected in that rulemaking effort. The BPT limitation is 7 mg/l 30 day average, 3.5 mg/l daily maximum.

SECTION II

FINAL REGULATIONS

BPT standards were promulgated on 26 April 1977 (42 FR 21380) based on the best practicable (BPT) control technology currently available. New source limitations (44 FR 2586) were also promulgated by the Agency on January 12, 1977 as required by the Clean Water Act of 1977. The Agency had reserved promulgation of limitations and standards for certain segements of the coal mining industry pending further data collection and analysis. The issues for further study included: (1) the appropriateness of a western mines subcategory, (2) the appropriateness of a post mining subcategory, (3) the type of storm relief granted to facility operators. Effluent limitations for the best available technology economically achievable (BAT) were proposed in January 13, 1981. Amendments to the BPT and NSPS regulations, primarily concerning the three issues listed above, were also proposed. The best conventional pollutant control technology (BCT) to treat conventional pollutants and the applicability of pretreatment standards and best management practices was also investigated in the proposed rulemaking. The resulting final regulations are presented below.

AMENDMENTS TO BPT REQUIREMENTS

Alternate Limitations During Precipitation Events

Previous studies by EPA contractors showed that TSS cannot be controlled consistently when it rains. Since those studies, EPA has instituted two sampling and analysis programs to characterize sedimentation pond performance parameters during various rainfall events. Results substantiate that settleable solids and pH can be effectively controlled during rainfall events (or snowmelt of equivalent volume) less than the 10-year, 24-hour design storm, as follows:

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Effluent Characteristic	Effluent Limitations*	
	Maximum for any one day	Average of daily values for 30 consecutive days shall not exceed
Settleable Solids	0.5 ml/l	---
pH	within the range 6.0 to 9.0 at all times	---

*The limitations in this table apply to overflows caused by precipitation or equivalent snowmelt volumes less than the 10-year, 24-hour event, except where noted.

Further, the EPA studies indicate that pH may be controlled for all storms, regardless of their size. Settleable solids were selected for regulation because pond performance during precipitation or increased flows due to snowmelt is much more consistent with regard to this parameter than for total suspended solids effluent levels. In contrast to the prior regulations and the proposed regulations, under this rulemaking, operators are no longer required to design their treatment facilities according to certain criteria. The Agency believes that operators should have maximum flexibility in meeting the effluent limitations with treatment systems designed for their specific situations.

Post Mining Discharges

Underground Mines

EPA determined that for inactive underground mines, the effluent limitations that apply to active mines during dry weather conditions will remain in effect until the performance bond issued under the Surface Mining Control and Reclamation Act (SMCRA) has been released. This will ensure that pollution abatement will continue unt effective sealing and reclamation practices have been instituted.

Surface Mines

The Agency has established limits on settleable solids and pH for reclamation areas as follows:

Effluent Characteristic	Effluent Limitations Maximum for any one day	 Average of daily values for 30 consecutive days shall not exceed
Settleable Solids	0.5 ml/l	----
pH	within the range 6.0 to 9.0 at all times	----

These limitations apply to areas where regrading has been completed and revegetation commenced, and will extend through the release of the applicable reclamation bond.

Western Mines

Previous BPT coal mining regulations did not apply to mines located in six specified western states (40 CFR 434.32(a)). However, based on review of data collected for this rulemaking, the Agency has determined that although western mines discharge less frequently than facilities located in the midwest and east, the effluent characteristics of discharges considered for regulation from western mines are very similar to discharges from mines in other geographic regions. These final regulations will therefore apply to all coal mines wherever located in the United States.

BCT EFFLUENT LIMITATIONS

As discussed in Section I, the BCT limitations are being reserved until a final BCT cost methodology is adopted by the Agency.

BAT EFFLUENT LIMITATIONS

Four subcategories were established for promulgation of effluent limitations based on the best available technology economically achievable (BAT):

1. Preparation plants and associated areas

2. Acid mine drainage
3. Alkaline mine drainage
4. Post mining discharges.

The limitations for acid mine drainage, post mining discharges at underground mines, and coal preparation plants and associated areas are based on neutralization and settling; those for alkaline drainage mines and reclamation areas are based on settling. For the coal mining industry, the BAT and BPT technologies are identical, so that the effluent limitations will be the same. The limitations guidelines appear in Table II-1. The modified BPT conditions will also apply for BAT, including the alternate limitations for rainfall. As in the BPT promulgation, a variance will be permitted on a case-by-case basis to allow effluent pH to slightly exceed 9.0 to achieve the manganese limitation for those subcategories subject to manganese limitations.

AMENDMENTS TO NEW SOURCE PERFORMANCE STANDARDS

Previously promulgated new source performance standards for the coal mining industry required achievement of pollutant levels based on BPT for all subcategories. NSPS is being amended by requiring achievement of pollutant levels based on the same technology proposed for BAT/BPT for each subcategory except preparation plants. NSPS for coal preparation plants are no discharge of wastewater pollutants based on complete water recycle system, a demonstrated technology for these facilities. Occasional purges from this system are permitted when necessary to reduce the concentration of solids or process chemicals in the water circuit to a level which will not interfere with the preparation process or process equipment. Facilities using the purge will be subject to alternate limitations (equal to BAT/BPT) while purging. The modified BPT conditions will also apply for NSPS except that alternate limitations during storms will not be available to new source preparation plants. NSPS limitations guidelines appear in Table II-2.

PRETREATMENT STANDARDS

Pretreatment standards are not established for the coal mining industry because there are no known existing situations in which such standards would be applicable. No indirect dischargers are known to exist in this category, nor are any anticipated.

Table II-1

EFFLUENT LIMITATIONS BASED ON BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE (BAT)

Subcategory and Effluent Characteristics	Effluent Limitations (mg/l)	
	Maximum for any one day	Average of daily values for 30 consecutive days shall not exceed
Preparation Plants and Associated Areas:		
Fe (total)	7.0	3.5
Mn*(total)	4.0	2.0
Acid Mine Drainage:		
Fe (total)	7.0	3.5
Mn (total)	4.0	2.0
Alkaline Mine Drainage:		
Fe (total)	7.0	3.5
Post Mining Discharges:		
Reclamation Areas (Surface)		
Settleable Solids	0.5 ml/l	---
pH (units)	within the range 6.0 to 9.0 at all times	---
Underground Mines		
Fe (total)	7.0	3.5
Mn*(total)	4.0	2.0

---

*If raw wastewater is acidic prior to any treatment.

Table II-2

NEW SOURCE PERFORMANCE STANDARDS (NSPS)

Subcategory and Effluent Characteristics	Effluent Limitations (mg/l)	
	Maximum for any one day	Average of daily values for 30 consecutive days shall not exceed
Preparation Plants:		
Fe (total)	NO DISCHARGE OF WASTEWATER* POLLUTANTS	
Mn (total)		
TSS		
pH (units)		
Associated Areas:		
Fe (total)	6.0	3.0
Mn (total)	4.0	2.0
TSS	70	35
pH (units)	within the range 6.0 to 9.0 at all times	---
Acid Mine Drainage:		
Fe (total)	6.0	3.0
Mn (total)	4.0	2.0
TSS	70	35
pH (units)	within the range 6.0 to 9.0 at all times	---
Alkaline Mine Drainage:		
Fe (total)	6.0	3.0
TSS	70	35
pH (units)	within the range 6.0 to 9.0 at all times	---
Post Mining Discharges: Reclamation Areas (Surface)		
Settleable Solids	0.5 ml/l	---
pH (units)	within the range 6.0 to 9.0 at all times	
Underground Mines		
Fe (total)	6.0	3.0
Mn**(total)	4.0	2.0
TSS	75	35
pH (units)	within the range 6.0 to 9.0 at all times	

---

*Except for occasional purges where necessary for operation.

**If raw wastewater is acidic prior to any treatment.

BEST MANAGEMENT PRACTICES (BMP)

For both surface mining and the surface effects of underground mining, the Department of Interior's Office of Surface Mining (OSM) under the Surface Mining Control and Reclamation Act has authority to promulgate specific regulations governing water management associated with mining and reclamation operations (44 FR 15143-15178). The resulting standards effectively establish a BMP program. Therefore, it is not EPA's intention to establish BMPs for coal mining under the authority established in the Clean Water Act. Rather, the effluent limitations and OSM's standards will provide a coherent and complementary framework for regulation of this industry. If, in the future, it becomes apparent that BMP's under the Clean Water Act are necessary to supplement OSM's program, EPA will propose them as appropriate.

SECTION III

INTRODUCTION

The purpose of this document is to provide support for the amendment of BPT and NSPS regulations and the promulgation of effluent limitations guidelines based on BAT and identification of pretreatment requirements under Sections 301, 304, 306, 307, and 501 of the Clean Water Act.

STATUTORY AUTHORITY

The regulations described in this document are promulgated under the authority of Sections 301, 304, 306, 307, and 501 of the Clean Water Act (the Federal Water Pollution Control Act Amendments of 1972, 33 U.S.C. 1251 et seq., as amended by the Clean Water Act of 1977, Public Law 95-217 (the "Act")). These regulations are also established in response to the Settlement Agreement in Natural Resources Defense Council, Inc., v. Train, 8 ERC 2120 (D.D.C. 1976), modified 12 ERC 1833 (D.D.C. 1979). The Federal Water Pollution Control Act Amendments of 1972 established a comprehensive program to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters" Section 101(a). By 1 July 1977, existing point source industrial dischargers were required to achieve "effluent limitations requiring the application of the best practicable control technology currently available" (BPT), Section 301(b)(1)(A). Further, by 1 July 1983, these dischargers were required to achieve "effluent limitations requiring the application of the best available technology economically achievable (BAT) which will result in reasonable further progress toward the national goal of eliminating the discharge of all pollutants" Section 301(b)(2)(A).

New industrial direct dischargers were required to comply with Section 306 new source performance standards (NSPS), based on best available demonstrated technology (BADT), and new and existing dischargers to publicly owned treatment works (POTWs) were subject to pretreatment standards under Sections 307(b) and (c) of the Act. While the requirements for direct dischargers were to be incorporated into National Pollution Discharge Elimination System (NPDES) permits issued under Section 402 of the Act, pretreatment standards were made enforceable directly against dischargers to POTWs (indirect

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dischargers). Table III-1 summarizes these levels of technologies, sources affected, and deadlines for promulgation and compliance. Although Section 402(a)(1) of the 1972 Act authorized the setting of requirements for direct dischargers on a case-by-case basis, Congress intended that, for the most part, control requirements would be based on regulations promulgated by the Administrator of EPA. Section 304(b) of the Act required the Administrator to promulgate regulations providing guidelines for effluent limitations setting forth the degree of effluent reduction attainable through the application of BPT and BAT. Moreover, Sections 304(c) and 306 of the Act required promulgation of regulations for NSPS, and Sections 304(f), 307(b), and 307(c) required promulgation of regulations for pretreatment standards. In addition to these regulations for designated industry categories, Section 307(a) of the Act required the Administrator to promulgate effluent standards applicable to all dischargers of toxic pollutants. Finally, Section 501(a) of the Act authorized the Administrator to prescribe any additional regulations "necessary to carry out his functions" under the Act.

Under the deadlines contained in Table III-1, EPA (the Agency) was required to promulgate many of these standards by mid-year in 1973. The Agency was unable to meet this requirement, and in 1976, EPA was again sued because many of the regulations required by the Federal Water Pollution Control Act Amendments of 1972 had not been promulgated. In settlement of this lawsuit, EPA and the plaintiffs executed a "Settlement Agreement" which was approved by the Court. This Agreement required EPA to develop a program and adhere to a schedule for promulgating for 21 major industries BAT effluent limitations guidelines, pretreatment standards, and new source performance standards for 65 "priority" pollutants and classes of pollutants. See Natural Resources Defense Council, Inc. v. Train, 8 ERC 2120 (D.D.C. 1976), modified, 12 ERC 1833 (D.D.C. 1979.)

On 27 December 1977, the President signed into law the Clean Water Act of 1977 (P.L. 95-217). Although this law makes several important changes in the federal water pollution control program, its most significant feature is its incorporation into the Act of several of the basic elements of the Settlement Agreement program for toxic pollution control. Sections 301(b)(2)(A) and 301(b)(2)(C) of the Act now require the achievement by 1 July 1984 of effluent limitations requiring application of BAT for toxic pollutants, including the 65 toxic pollutants and classes of pollutants which Congress declared toxic under Section 307(a) of the Act. Likewise, EPA's programs for new source performance standards and pretreatment standards are now aimed principally at toxic pollutant controls. Moreover, to strengthen the toxics control program, Congress added Section 304(e) to the Act, authorizing the Administrator to prescribe "best management practices" (BMPs) to prevent the release of toxic and hazardous pollutants from plant site runoff, spillage or leaks, sludge or waste disposal, and drainage from raw material storage associated with, or ancillary to, the manufacturing or treatment process.

Table III-1
THE FEDERAL WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972

Level of Technology	Section of Act	Sources Affected	Deadline for EPA for Promulgation	Deadline for Operator Compliance
BPT	301, 304	Existing sources	1 yr. after passage	July 1, 1977
BAT	301, 304	Existing sources	1 yr. after passage	July 1, 1983
BADT	306	New sources	1 1/3 yr. after passage	effective upon promulgation
PSES	307	Existing sources discharging to POTW	270 days after passage	no later than 3 years after promulgation
PSNS	307	New sources discharging to POTW	1 1/3 yrs. after passage	effective upon promulgation

In keeping with its emphasis on toxic pollutants, the Clean Water Act of 1977 also revised the control program for non-toxic pollutants. Instead of BAT for "conventional" pollutants identified under Section 304(a)(4) (including biochemical oxygen demand, suspended solids, fecal coliform, pH, and oil and grease), the new Section 301(b)(2)(e) requires achievement by 1 July 1984, of "effluent limitations requiring the application of the best conventional pollutant control technology" (BCT). The factors considered in assessing BCT for an industry include the costs of attaining a reduction in effluents and the effluent reduction benefits derived compared to the costs and effluent reduction benefits from the discharge of publicly owned treatment works Section 304(b)(4)(B). For non-toxic, nonconventional pollutants, Sections 301(b)(2)(A) and (b)(2)(F) require achievement of BAT effluent limitations within three years after their establishment or 1 July 1984, whichever is later, but not later than 1 July 1987.

PRIOR EPA REGULATIONS

On 17 October 1975, EPA proposed regulations adding Part 434 to Title 40 of the Code of Federal Regulations (40 FR 48830). These regulations, with subsequent amendments, established effluent limitations guidelines based on the use of the best practicable control technology currently available (BPT) for existing sources in the coal mining point source category. These were followed, on 26 April 1977, by final BPT effluent limitations guidelines for this category (42 FR 21380). On 19 September 1977, the Agency published proposed new source performance standards (NSPS) within this industrial category based on application of the best available demonstrated control technology (42 FR 46932). On 12 January 1979, EPA promulgated final NSPS for this industry (44 FR 2586). Both the BPT and NSPS regulations contained an exemption from otherwise applicable requirements during and after catastrophic precipitation events. These storm exemptions were re-examined, subjected to further public comment, and ultimately revised on 28 December 1979 (44 FR 76788). Moreover, the NSPS regulations contained a definition of "new source coal mine" which was challenged by petitioners in Pennsylvania Citizens Coalition et al. v. EPA. 14 ERC 1545 (3rd Cir. 1980). In response to the Court's decision in that case, the Agency amended its definition of a "new source coal mine" on 27 June 1980 (45 FR 43413).

RELATIONSHIP TO OTHER REGULATIONS

The coal mining industry has been subject to a variety of federal and state regulations during its history. The Surface Mining Control and Reclamation Act of 1977 (SMCRA-P.L. 95-87, 30 U.S.C. 1251-1279) established statutory authority for regulatory development with an Office of Surface Mining, Reclamation, and Enforcement (OSM) within the Department of the Interior (DOI). For both surface mining and the surface effects of underground mining, OSM has promulgated specific regulations governing water management associated with mining and reclamation operations (44 FR 15143). A number of these standards have been recently remanded as a result of litigation; OSM is now in the process of a new rulemaking. EPA and OSM have and will continue to work closely in establishing a comprehensive, efficient program for regulation of surface coal mining operations.

OVERVIEW OF THE INDUSTRY

The Standard Industrial Classification (SIC) Categories reviewed and discussed in this document include the following:

1. SIC 1111 Anthracite Mining,
2. SIC 1112 Anthracite Mining Services,
3. SIC 1211 Bituminous Coal and Lignite Mining, and
4. SIC 1213 Bituminous Coal and Lignite Mining Services.

The coal mining industry extracts and processes coal, a black, primarily organic substance formed from compressed layers of decaying organic matter millions of years ago. Depending upon the fixed carbon content, the volatile matter fraction, and the heating value, coals are classified by ranks generally as lignite, subbituminous, bituminous, and anthracite. The primary end uses of the material are for combustion in steam boilers or metallurgical coke ovens with a large potential market for coal conversion facilities in the synthetic fuels industry. The industry can be broadly classified into extraction (mining) and processing (preparation). The industry currently operates in 26 states; mines are located in Appalachia, the Midwest, the Great Plains, and the Mountain and Pacific regions. In 1980, 6,300 coal mining operations were active; 70% of these mines are located in the eastern part of the country, as opposed to 30% in the western United States. The western mines are characteristically newer and much larger than most eastern mines. In addition, there are currently about 540 coal preparation plants using wet coal cleaning methods in the country. Total coal production in the U.S. in 1980 was 830,000,000 short tons (1). Because of the many political, environmental, and economic factors that impact the U.S. energy supply picture, projections for increases in domestic coal production are widely variable. Most estimates target production in 1985 at around one billion short tons per year. By 1990, this projected tonnage will increase to approximately 1.2 billion short tons per year (2, 3). Fifty years ago underground mines accounted for almost 96 percent of all coal production in the U.S. each year. Surface mining has slowly increased such that in 1982, 60% of coal production is from surface mines (4). This rapid growth of surface mining was made possible by improved machinery and mining methods, the general geology of the coal fields, and the rapid expansion of the western surface mined coal fields.

SUMMARY OF METHODOLOGY

Analysis of the sources, levels, and applicable treatment processes for toxic, non-conventional, and conventional pollutants in coal mining wastewaters forms the basis for this study. To establish effluent limitations guidelines, a data collection program was initiated in 1976 to profile the coal mining industry. This data collection program will augment the data base previously developed for BPT requirements.

The first step in the BAT review involved characterization of toxic compounds in coal mine wastewaters in accordance with the Settlement Agreement executed by NRDC and EPA in June of 1976. No general survey questionnaire under authority of Section 308 of the Clean Water Act was attempted at the outset of this study because over 6,000 mines are in active operation today. Therefore, representative mines to characterize the entire industry were selected for sampling. The sampling program was initiated in two phases-screening sampling and verification sampling. The screening program established the general characteristics of mine and preparation plant drainage.

After the screening sampling effort was well underway, verification sampling was initiated. This program entailed more extensive composite sampling with special regard for those priority pollutants identified from the screen sampling program. Levels of detected pollutants were quantified. The effluent characteristics were used to evaluate and, if necessary, modify the BPT subcategorization scheme. In addition, pollutants to be regulated for BAT and NSPS were identified. The results of the screening and verification program were examined to determine pollution control needs.

Several candidate treatment technologies were then identified to control pollutant discharges. The techniques identified for removal of organics include neutralization, aeration, ozonation, carbon adsorption, and sand filtration. A pilot treatment unit was assembled at the EPA Crown Mine Drainage Control site to test the above technologies on coal mine drainage. The primary focus of this treatability study was to quantify the removals of organic pollutants by the various control technologies. A number of environmental control processes that reduce toxic and other metallic pollutants in mine drainage were also evaluated. A treatability study was performed by EPA's Office of Research and Development for metals removal achieved by lime neutralization, ion exchange, and reverse osmosis (5). Additionally, the Agency commissioned three treatability studies in 1979-80 to quantify removals of priority metals from acid mine drainage by the use of flocculant addition and granular media filtration.

Another important facet of this study is the development of costs associated with purchase, installation, and operation of treatment equipment. Cost curves were developed from model plants. These costs were verified by site visits to 17 facilities. At the facilities, site-specific cost data were collected. Actual costs were compared to model plant costs. Additional data were collected to gain a more accurate profile of coal preparation plants, particularly in reference to water management practices and total recycle systems. To implement this effort, EPA, with the cooperation of the National Coal Association (NCA), disseminated a questionnaire to NCA member companies. Information gathered from the 152 respondents indicates that approximately 34 percent of the U.S. preparation plants are currently operating a total recycle system with diversion of storm water. Additionally, a classification scheme for different size plants with varying requirements for achievement of zero discharge was developed for costing purposes. Costs for retrofitting the industry for total water recycle were developed.

In addition, a study was performed to determine sedimentation pond performance at various coal mining operations around the country during precipitation events and for reclamation areas. Another study followed to determine the precision and accuracy in measuring one of the regulated parameters (settleable solids) during storms and reclamation.

Report Organization

The Industry Profile, Section IV, includes background information on the history and geology of coal, production and other important statistics, mining techniques, and water use and management within the coal industry. This characterization of the industry will provide a foundation for analysis of water use and wastewater generation and treatment.

Section V, Wastewater Characterization and Industry Subcategorization, summarizes data collected on the levels of pollutants from a two phase sampling program. Twenty-three mines and facilities were visited during the screening phase; four sites from screening were revisited and five additional sites were sampled during the verification phase. This screening and verification program was conducted primarily to identify and quantify levels of toxic pollutants in coal mine wastewaters.

In Section VI, Selection of Pollutant Parameters, all 129 priority pollutants as well as the currently regulated parameters-- TSS, pH, iron, and manganese--are discussed in light of their source, level, and treatability. After selection of the pollutants to be regulated, a candidate list of treatment technologies to reduce or eliminate these parameters was prepared. The achievable effluent pollutant reductions are quantified, using results from EPA treatability studies as well as pilot studies conducted by other governmental agencies and industry.

These control options and a review of water management practices are presented in Section VII, Treatment and Control Technology. The processes that are technically suitable are then further analyzed according to their cost effectiveness, energy requirements, and secondary pollution potential. The section also describes treated effluent data from 24 sedimentation ponds visited in the final segment of the BAT review in order to determine effluent pond characteristics during precipitation events and for reclamation areas. This section also discusses the results of a data collection effort conducted in order to determine the precision and accuracy of measuring settleable solids below 1.0 ml/l. Finally, this section includes a summary of the results obtained during an investigation of effluent characteristics from areas under reclamation to determine treatability of and the need for "post-bond" release regulations.

These factors are presented in Section VIII: Cost, Energy, and Non-Water Quality Issues. Cost information contained in this report was obtained from industry during plant visits, engineering firms, equipment suppliers, and from the literature. The information obtained was used to develop capital and operating costs for each treatment and control method. Where data were lacking, costs were developed from knowledge of equipment required, processes employed, and construction and maintenance requirements. An economic analysis to determine the impact on the industry of installing the technically feasible treatment option(s) was conducted using the costs developed herein. This assessment is reported separately by EPA.

Section IX details the amendments made to the BPT regulation.

The BAT options are presented in Section X. All data obtained were evaluated to determine what levels of treatment constituted reasonable alternatives for consideration as the "best available technology economically achievable" (BAT). Several factors were considered in identifying technologies. These included the age of equipment and facilities involved, the process employed, engineering aspects of the application of various types of control techniques or process changes, the cost of achieving effluent reduction, non-water quality environmental impacts, and energy requirements. Efforts were also made to determine the feasibility of transfer of technology from subcategory to subcategory, other categories, and other industries where similar effluent problems might occur. Consideration of the technologies was not limited to those presently employed in the industry, but included those processes in pilot plant or laboratory research stages. This section includes a discussion of the best management practices (BMP) program. New source performance standards (NSPS), which are discussed in Section XI, are selected based on the best available demonstrated technology (BADT). The best demonstrated process changes, in-plant controls, and end-of-pipe treatment technologies which reduce pollution to a minimum are considered. Section XII summarizes the rationale for not establishing pretreatment regulations for this industry.

Appendix A, "Coal Mining Industry Self Monitoring Program", describes a study conducted by EPA on 24 sedimentation ponds to determine the appropriate settleable solids and pH limitations for mines during precipitation events.

Appendix B, "Coal Mine Drainage - Precision and Accuracy Determination for Settleable Solids at Less Than 1.0 ml/l", describes a study EPA conducted which resulted in establishing a new settleable solids method detection limit for the coal mining industry.

Appendix C, "Investigation of Post-Mining Discharges after SMCRA Bond Release", describes a study EPA conducted on effluent discharges after active mining ceases.

SECTION IV

INDUSTRY PROFILE

INTRODUCTION

The purpose of this section is to profile the U.S. coal mining industry and its water usage according to a number of descriptive parameters. The origin and chemistry of coal are described prior to a discussion of water use within the mining and preparation segments of the industry. The history, future, and location and production aspects of coal mining are then presented. The section concludes with a discussion of industry processes and methods.

ORIGIN AND CHEMISTRY OF COAL

Origin

Coal had its origin in the accumulation and physical and chemical alteration of vegetation. More precisely, conditions necessary for the accumulation of peat and subsequent formation of coal are as follows:

1. Swamp or marsh environment and climate favorable to plant growth.

2. Some subsidence of the area during accumulation of vegetal debris, or compaction of deposited plant material, permitting further accumulation.

3. Sufficiently wet conditions to permit exclusion of air from much of the vegetal material before it decays, and sufficiently rapid accumulation to thwart bacterial action, even within the swamp water. The acidity of this water normally prevents bacterial action at a few inches or a few feet below the water level in the swamp.

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4. Proximity to the sea or a sinking area so that vegetable material can be buried by sediments when the sea level rises or the land subsides.

5. Site of accumulation such that removal by erosion does not subsequently occur.

As peat accumulated, the weight of the top layers of peat compacted the lower layers, primarily by squeezing out large amounts of water. Various chemical effects and bacterial action on the vegetal debris also took place in the swamp environment. Burial by sediments, physical-chemical effects associated with the changed environment, and loss of water and volatile materials resulted in formation of lignite, the earliest stage in the formation of coal. With increasingly deeper burial, pressure continues to compress the lignite, and the increase in heat associated with the increasing depth of burial will further devolatize the coal- forming materials. The rank (Table IV-1) of the coal became progressively higher, rising from lignite through subbituminous, bituminous, semianthracite, and anthracite to meta-anthracite. Estimates indicate that about three to seven feet of reasonably compacted plant material is required to form one foot of bituminous coal (1).

Chemistry

The chemical constituents in coal determine its characteristics. These characteristics depend on:

1. The type of vegetation from which the coal was originally formed;

2. The pressure to which the decaying vegetation was subjected;

3. The foreign matter, whether wind or waterborne, that was deposited on the decaying vegetation while it was being converted into coal, or the foreign matter that infiltrated while in solution after the coal was formed; and

4. The heat to which the decaying vegetation was subjected.

The environmental conditions under which the coal was formed are the primary determinants of the coal's chemical and physical properties. For instance, coals in the Illinois seams were inundated by marine water soon after formation, imparting a high concentration of sulfur. Low-sulfur coals are often found in areas where fresh water conditions prevailed. As codified by the International Committee for Coal Petrography, the ultimate microscopic constituents of coal are a series of macerals, which are characterized by their appearance, chemical composition, and optical properties, and which can, in most

Table IV-1

CLASSIFICATION OF COALS BY RANK

Class	Group	Fixed Carbon Limits, % (Dry Mineral-Matter-Free Basis)		Volatile Matter Limits, % (Dry, Mineral-Matter-Free Basis)		Calorific Value Limits, Btu per Lb (Moisture,[2] Mineral-Matter-Free Basis)		Agglomerating Character
		Equal or Greater Than	Less Than	Greater Than	Equal or Less Than	Equal or Greater Than	Less Than	
I. Anthracitic	1. Meta-anthracite	98	..	..	2	..	..	Nonagglomerating
	2. Anthracite	92	98	2	8	..	..	
	3. Semianthracite[3]	86	92	8	14	..	..	
II. Bituminous	1. Low-volatile bituminous coal	78	86	14	22	..	..	Commonly agglomerating[5]
	2. Medium-volatile bituminous coal	69	78	22	31	..	..	
	3. High-volatile A bituminous coal	..	69	31	..	14,000[4]	..	
	4. High-volatile B bituminous coal	..	..	..	..	13,000[4]	14,000	
	5. High-volatile C bituminous coal	..	..	..	..	11,500	13,000	
						10,500	11,500	Agglomerating
III. Subbituminous	1. Subbituminous A coal	..	..	..	..	10,500	11,500	Nonagglomerating
	2. Subbituminous B coal	..	..	..	..	9,500	10,500	
	3. Subbituminous C coal	..	..	..	..	8,300	9,500	
IV. Lignitic	1. Lignite A	..	..	..	..	6,300	8,300	
	2. Lignite B	..	..	..	..	..	6,300	

(1) This classification does not include a few coals, principally nonbanded varieties, which have unusual physical and chemical properties and which come within the limits of fixed carbon or calorific value of the high-volatile bituminous and subbituminous ranks. All of these coals either contain less than 48 percent dry, mineral-matter-free fixed carbon or have more than 15,500 moisture, mineral-matter-free Btu per lb.

(2) Moisture refers to coal containing its natural inherent moisture but not including visible water on the surface of the coal.

(3) If agglomerating, classify in low-volatile group of the bituminous coal.

(4) Coals having 69 percent or more fixed carbon on the dry, mineral-matter-free basis shall be classified according to fixed carbon, regardless of calorific value.

(5) It is recognized that there may be nonagglomerating varieties in these groups of the bituminous class, and there are notable exceptions in high-volatile C bituminous group.

Source: American Society for Testing and Materials, D388 cases, be traced to specific components of the plant debris from which the coal formed. Macerals are further grouped by appearance into three major maceral groups. Coal macerals and maceral groups recognized by the International Committee for Coal Petrography are presented in Table IV-2.

Coal, in general, has a lamellated (thin-layered) structure comprised of both organic and mineral matter. Inherent minerals (minerals confined within the coal structure) are primarily iron, phosphorous, sulfur, calcium, potassium, and magnesium; these comprise less than two percent (by weight) of the coal (3). A great many trace elements are also found in coal; these are shown in Table IV-3. Though coal is primarily organic, specific information regarding organic constituents is not readily available, excepting ultimate analyses.

Extraneous coal mineral matter (ash) is matter that was deposited simultaneously with the peat, or through cracks following peat consolidation. Ash content generally ranges from 3 to 20 percent (by weight) and averages 10 percent. Major constituents are shown in Table IV-4. The chemical composition of coal ash varies greatly. It is a mixture of silica (SiO_2) and alumina (Al_2O_3), which comes from sand, clay, slate and shale; iron oxide (Fe_2O_3), from pyrite and marcasite; magnesia (MgO) and lime (CaO), from gypsum and limestone; the alkalies, sodium oxide and potassium oxide (Na_2O and K_2O);phosphorus pentoxide (P_2O_5); plus trace amounts of antimony, arsenic, barium, beryllium, boron, cadmium, cobalt, copper, germanium, gold, lead, manganese, mercury, platinum, scandium, selenium, silver, tin, titanium, uranium, vanadium, yttrium, and zinc.

Inorganic sulfur, usually in the form of pyrite, is the constituent in coal that often results in the formation of acid waters. Such effluent develop where the inorganic (pyritic) sulfur in exposed coal is oxidized to SO_2 and a variety of iron sulfates. These constituents then partially combine with the hydrogen in water to produce sulfuric acid (H_2SO_4), which leaches additional metals. It is important to note that organically bound sulfur, generally believed to be in complex combination with the organic constituents of coal, does not participate in these oxidation processes, and that coals containing little pyrite consequently pose no environmental hazards from acid mine waters or runoffs even if their total sulfur contents are substantial.

Sulfur infiltrated coal in a number of ways. Sulfur was usually present in the swamp, and some of it was taken up by the plants. Under certain conditions, sulfur in the peat swamp was converted to the mineral pyrite. Sulfur also appears to have been introduced into the coal seam after the peat had been converted to coal. This is evident by the appearance of pyrite coatings on vertical fracture surfaces in the seam. Much of the pyrite present occurs as very small crystalline grains intimately mixed with the organic constituents of coal. The origin of sulfur in large concretions, nodules, lenses and bands, and filling in porous layers of coal, is only partially understood, but the relationship between the high-sulfur content of

Table IV-2

COAL MACERALS AND MACERAL GROUPS RECOGNIZED BY THE INTERNATIONAL COMMITTEE FOR COAL PETROGRAPHY

Maceral Group	Symbol	Maceral	Composed of or Derived From
Vitrinite	V	Collinite	Humic gels
		Tellinite	Wood, bark, and cortical tissue
		Vitrodetrinite[a]	
Exinite	E	Sporinite	Fungal and other spores
		Cutinite	Leaf cuticles
		Resinite	Resin bodies and waxes
		Alginite	Algal remains
		Liptodetrinite[a]	
Inertinite	I	Micrinite	Unspecified detrital matter, <10 m
		Macrinite[b]	Similar, but 10-100 m grains
		Semifusinite	
		Fusinite	"Carbonized" woody tissues
		Sclerotinite	
		Inertodetrinite[a]	

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[a] These terms are applied to small entities that, because of their reflectivity, must be assigned to this maceral group, but that cannot be unequivocally identified with any particular maceral within the group. Thus, vitrodetrinite is used to designate a maceral when it is not possible to distinguish between collinite and tellinite, and liptodetrinite is used where, e.g., it is impossible to differentiate between sporinite and cutinite on morphological grounds.

[b] This is sometimes also referred to as massive micrinite.

Source: (2)

Table IV-3

TRACE INORGANIC ELEMENTS IN COAL

Trace Inorganic Elements
(about 0.1% or less, on ash)

Beryllium
Fluorine
Arsenic
Selenium
Cadmium
Mercury
Lead
Boron
Vanadium
Chromium
Cobalt
Nickel
Copper
Zinc
Gallium
Germanium
Tin
Yttrium
Lanthanum
Uranium
Lithium
Scandium
Manganese
Strontium
Zirconium
Barium
Ytterbium
Bismuth

Source: (2)

Table IV-4

MAJOR INORGANIC CONSTITUENTS OF COAL, ASH PORTION

Major Inorganic Constituent	Forms in Coal	
Silicon	Silicates and sand	
Aluminum	Aluminum in combination with silica	
Iron	Pyrite and marcasite (sulfide)	
	Ferrous oxide	
	Ferrous carbonate	
	Ferrous sulfate	
	Ferric oxide	In small quantities
	Ferric sulfate	
	"Organic" iron	
	Iron silicates	
Calcium	Lime, carbonate, sulfate, silicates	
Magnesium	Carbonates, silicates	In small quantities
Sodium and potassium	Silicates, carbonates, chlorides	
Manganese	Carbonates, silicates	
Sulfur (inorganic)	Pyrite and marcasite	
	Ferrous sulfate	
	Ferric sulfate	In small quantities
	Calcium sulfate	
Phosphorus	Phosphates	

Source: (2)

coals and the sediments immediately overlying the coals that were clearly deposited in a marine environment strongly suggests that seawater was the source of much of the sulfur found in coal.

INDUSTRY WATER USE

Coal Mining

Water usage in the coal mining industry is different than in other major industries for a number of reasons. First, water is a hindrance to operation of strip and underground mining machinery. Second, water is used in the mining of coal primarily for dust suppression (i.e., haulroads, continuous miners, conveyor belts, coal stockpiles in some cases, etc.) and equipment cooling. Third, coal mines often occupy hundreds of acres of land subject to a high amount of precipitation. Therefore, pollution abatement must be approached differently, with reliance on operating and management practices for source control as well as end-of-pipe treatment technologies. Water is also used to a very limited extent for irrigation of reclaimed lands. In some areas with extremely low precipitation, irrigation research is being conducted on an experimental basis by the U.S. Forest Service, using the sprinkler and drip methods. It appears doubtful, however, that irrigation on an extensive scale, and as a viable reclamation measure, is going to be practicable (4).

Water entering mine areas because of precipitation, ground water infiltration, and surface runoff is a hindrance; removal of water from the active mining area is required at most mines to ensure the continuity, efficiency, and safety of the mining operation. Water infiltration is generally less severe in the semiarid west, unless the mine is located within a major aquifer.

All flow data available on mine drainage were assembled to determine whether or not flow of wastewater could be correlated with production. These data came from three sources: the BPT development document; a survey by Bituminous Coal Research, Inc.; and the screening phase of the BAT study. The data show that water volume (or flow) encountered during the coal mining operation cannot be related to coal production (see Figure IV-1), nor can it be expressed in the classic waste management terms of volume per weight of product. There are a number of variables that preclude such a relationship, including climatology, location of aquifers, amount of disturbed acreage, characteristics of individual watersheds, and rate of coal extraction.

Flows from acid and alkaline mines, and surface and underground mines, were examined for significant statistical differences. The data indicate no statistical difference in the amount of water pumped by

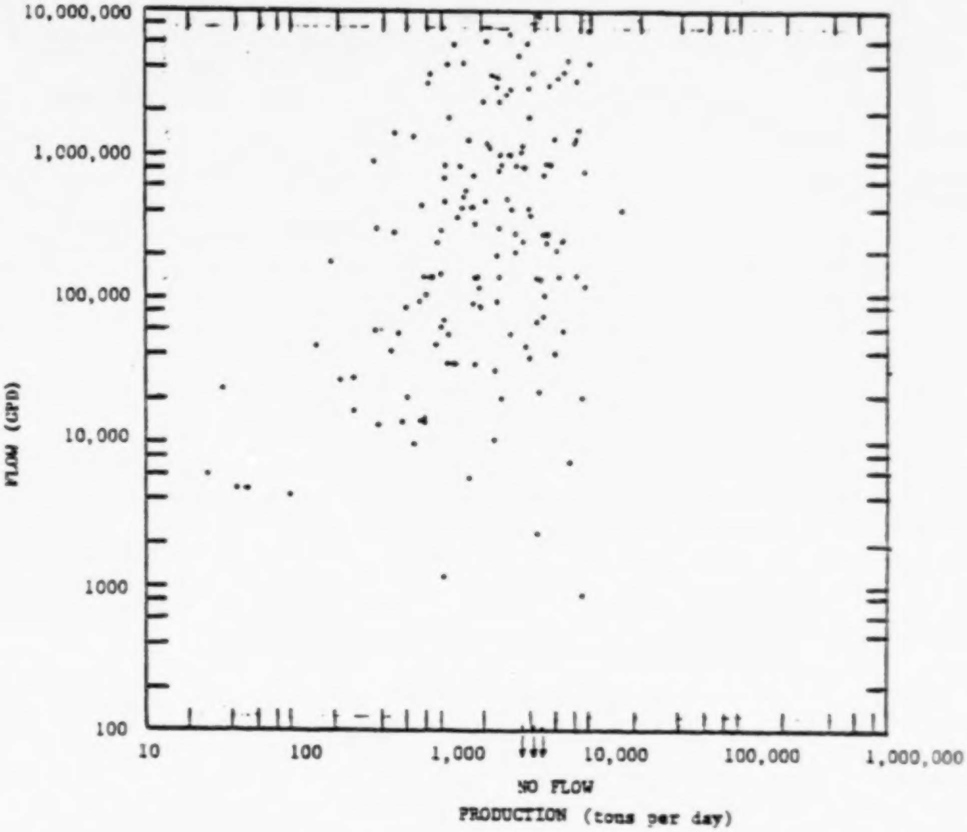

Figure IV-1
SCATTER DIAGRAM OF COAL MINE PRODUCTION
AND MINE DRAINAGE

Source: (5)

various mines based on the factors listed above. Therefore, all mines were classed together and plotted against production to identify any correlation (see Figure IV-1). A regression analysis performed on this data shows no correlation.

The correlation coefficient (r^2) for 140 coal mines is 0.18 with a slope for the least square line of 0.04. A distribution curve for the volume of water pumped by bituminous and lignite mines is presented in Figure IV-2. Eighty percent of the flow volumes fall between 7,000 gallons per day (GPD) and 4.5 million gallons per day. The median flow (50 percent) is 250,000 GPD. The mean flow, 995,000 GPD, is at the 75th percentile.

Coal Preparation

Water use in coal preparation differs from that in coal mining. Here, water is intentionally introduced into the coal preparation process. Unit operations such as wet screening, tables, jigs, cyclones, gravity separation, heavy media separation, and froth flotation require water. Water is also used for dust control, for equipment cooling, and as a medium to transport coal between unit operations. The coal industry has witnessed a gradual decline in the use of dry methods of coal preparation in favor of wet techniques (6). Present cleaning technologies were introduced with the adoption of mechanized mining, which do not differentiate between coal and impurities, and results in an increase of fines in run-of- mine coal. The need to wet clean coal has been further stimulated by more explicit quality specifications by utility customers and other consumers of coal. As the need for wet cleaning of coal increased, water use in preparation plants also increased (6).

A major portion of the water used in coal preparation is recirculated because of economic considerations; that is, the need to obtain suitable feed water and the need to comply with state and federal requirements for effluent discharges (6). Currently, however, there sometimes are emergency spillways which allow discharges during rainstorms or equipment breakdowns, etc. Many preparation plants are designed to operate on a closed water system as a matter of economics and to help meet water quality requirements. However, a need sometimes arises for a blowdown or purge in a total recycle system to reduce dissolved solids.

Water usages from new preparation plant designs are presented in Table IV-5 and are compared with water usages from preparation plants (ranging from 3 to 41 years in age) visited in this study. In new closed- circuit plant designs (indicated by *), the data indicate that the amount of water used in the beneficiation process increases with the level of cleaning, or the amount of fine coal cleaning. However, the data do not establish any relationship between amount of coal cleaned and volume of water discharged, nor does it establish any industry-wide relationship between amount of water used and level of cleaning for older plants.

Table IV-5

WATER USE IN PREPARATION PLANTS BY LEVEL OF CLEANING AND TYPE OF COAL CLEANED

Level of Cleaning	Plant	Amount of Water Circulated per ton of Coal Cleaned, gal/ton	Type of Coal Cleaned
2	Bechtel*	112	Low Sulfur Eastern
	NC-10	1,190	High Sulfur Eastern
	NC-22	360	High Sulfur Eastern
3	Bechtel*	327	Low Sulfur Western
	NC-20	1,800	Medium Sulfur Eastern
4	Bechtel*	500	High Sulfur Eastern
	NC-3	483	Low Sulfur Western
	NC-14	3,050	High Sulfur Eastern
	NC-16	480	Low Sulfur Eastern
	NC-11	2,000	Low Sulfur Eastern
	NC-15	850	Low Sulfur Eastern
	NC-18	480	Medium Sulfur Eastern

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* New closed-circuit design

Source: (7)

** Level 2 - Course Size Coal Beneficiation
Level 3 - Course and Medium Size Coal Beneficiation
Level 4 - Course, Medium and Fine Size Coal Beneficiation

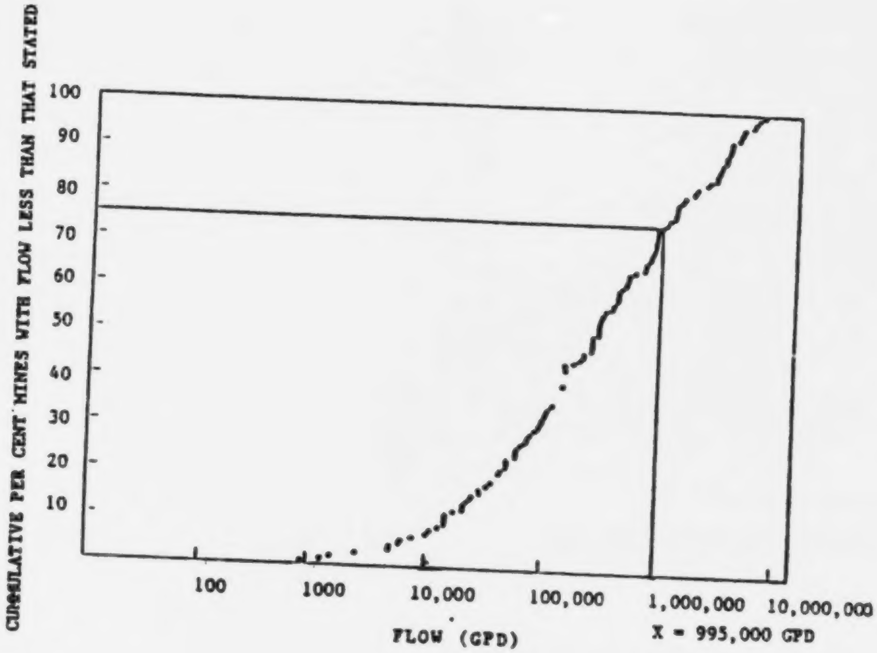


Figure IV-2
FLOW DISTRIBUTION OF COAL MINES

Source: (5)

HISTORY

Coal was first commercially mined in America in 1750, from the James River coal field near Richmond, Virginia. However, coal was not widely utilized until well into the 19th century because abundant forests supplied nearly all of the needed fuel. Total anthracite and bituminous coal consumption was only 98,000 metric tons (108,000 short tons) in 1800. Thereafter, consumption gradually increased until it superseded wood for the first time in 1840, after which coal mining became increasingly more important due to the development of railroads, steel mills, and other large consumers of fuel.

After the Civil War, industrial development grew very rapidly, causing coal consumption to reach 181 million metric tons (200 million short tons) annually by 1900 and 454 million metric tons (500 million short tons) by 1910. Bituminous and lignite production temporarily peaked at 572 million metric tons (630 million short tons) in 1947, falling off to 356 million metric tons (392 million short tons) in 1954, and finally surpassing the 1947 high when 588 million metric tons (648 million short tons) were produced in 1975. In 1979, a new record for coal production was achieved of 770,000,000 short tons and increased to 830,000,000 short tons in 1980. Figure IV-3 shows U.S. consumption of coal by end-use sector.

In the early 1800's, anthracite production was greater and more important than bituminous coal, but, by 1870, anthracite and bituminous production were equal, and by 1901, bituminous production was four times greater. Total anthracite production continued to increase, however, until it peaked at 90.3 million metric tons (99.6 million short tons) annually during the World War I period (1917). Thereafter, its steady decline has lowered its production to 4.6 million metric tons (5.0 million short tons) for 1978. Anthracite's early popularity can be attributed to its high quality, use by the railroads, and proximity to major population centers where its clean-burning characteristics made it a favorite for space heating. The steady decline of the use of anthracite was caused by the high production of more convenient and cheaper natural gas, oil, and bituminous stoker coal. Table IV-6 and Figure IV-4 portray the history of anthracite coal production in the United States.

Surface Mining

Coal was first extracted by surface methods; however, the development of surface mining techniques was insignificant until around 1910 when steam-powered shovels were developed. Initially, truck-mounted shovels were used, but they only had a swing of 180 degrees. Later, a wood frame, 360 degree shoven was built, and from then on the development of surface mining was rapid. By the 1930's, rail-mounted shovels were being replaced by those mounted on crawler tracks (i.e., dozer-type tracks), while steam power was being replaced by electric.

Table IV-6

HISTORY OF U.S. ANTHRACITE PRODUCTION

Year	Production (kkg - 10^6)[1]
1890	42.156
1900	52.043
1910	76.644
1920	81.282
1930	62.945
1940	46.706
1950	39.986
1960	17.071
1970	8.826
1975	5.628
1976	5.650
1977	4.591
1978	4.569

(1) Multiply by 1.1023 to obtain short (English) tons.

Sources: Years 1890-1976: (9)
1977-1978: (10)

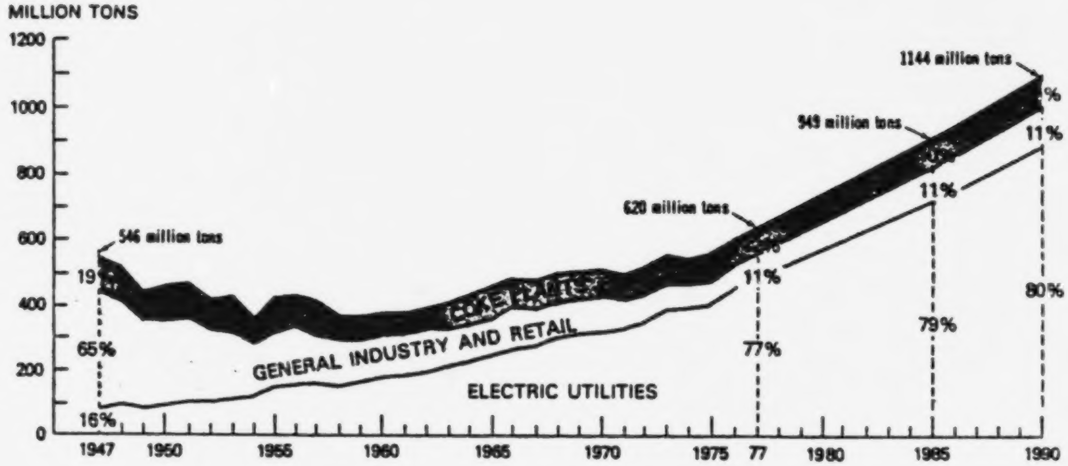


Figure IV-3
U.S. CONSUMPTION OF COAL BY END-USE SECTOR

Note: Percentage figures represent percent shares of total consumption.

Source: (8)

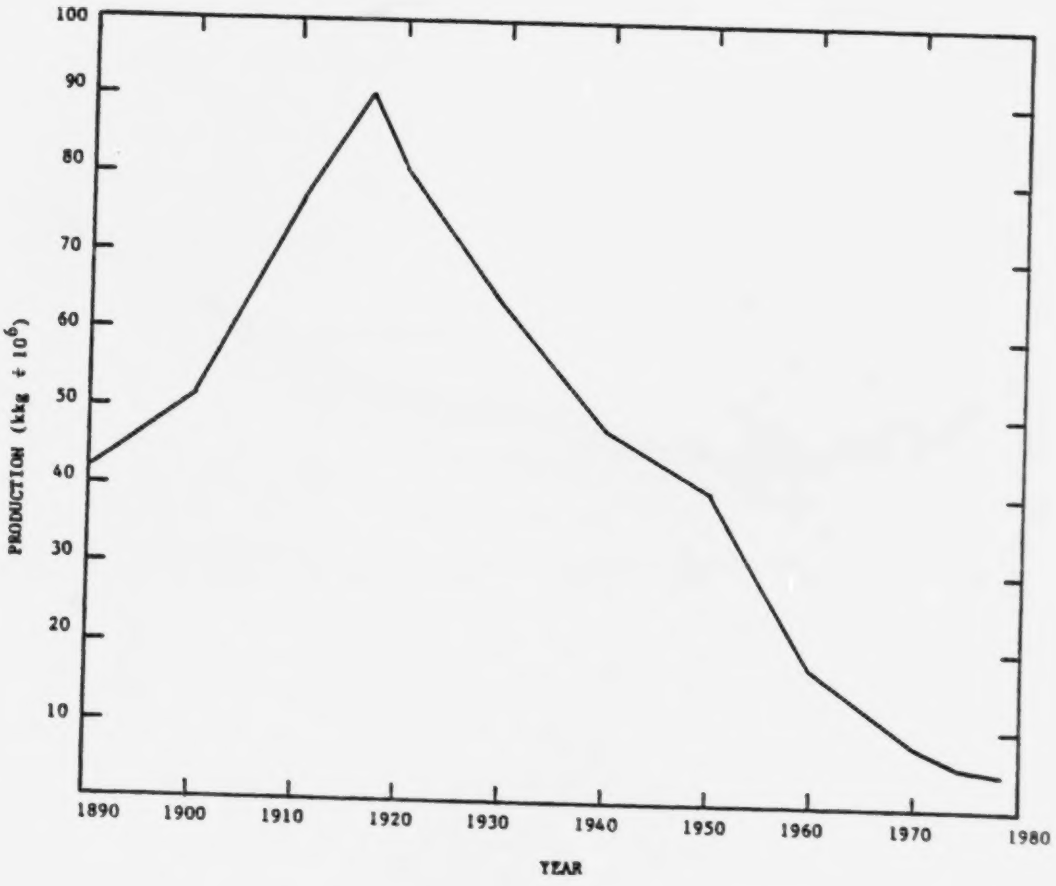


Figure IV-4
HISTORY OF U.S. ANTHRACITE PRODUCTION

Source: (11)

During this same period, track haulage of coal with small side-dump cars were replaced by trucks.

These developments helped spur a steady increase in surface mine production for almost every year since 1920. In 1978, surface mine production comprised 63 percent of total U.S. production. This rapid growth was also made possible by constantly improving machinery and mining methods and by the general geology of the coal fields. Contour strip mining was first applied in the Appalachian fields where a combination of surface topography and coal beds frequently presented sizable areas along the outcrop (where the coal seam contacts the surface) with low overburden (dirt and rock material covering the coal) depth. In Ohio, the Midwest, North Dakota, and the Rocky Mountain states, large coal mining areas exist in gently rolling or nearly flat terrain; therefore, area strip mining methods are preferred to contour stripping.

This condition helped promote high output mines which utilize even larger and more efficient draglines, shovels, end loaders, truck drills, and other auxiliary equipment. One of the most recent developments has been the use of wheeled front-end loaders for loading both coal and overburden. Hydraulic shovels are also being utilized more frequently. Bucket-wheel excavators are in use where conditions permit. Wheeled tractor scrapers are finding more and more acceptance for overburden removal. Numerous other new surface mining techniques and equipment are being studied; for example, continuous excavating machines that can increase overburden removal rates.

Underground Mining

Coal was initially mined by hand using a pick and bar, then shoveled into baskets or wheelbarrows. This progressed into cars drawn over wood planks, cars drawn over iron straps, and eventually cars drawn over rails by dogs or horses. Black powder was introduced to blast down the coal while undercutting, sidecutting, and drilling were still done by hand. Other developments during the 18th and 19th centuries which aided mining included: invention of the steam engine in 1775 to pump water out of the mine, making it possible for mines to go deeper; development of the first steam locomotive in 1814, leading to surface rail transportation of coal; and development of the first electric locomotive in 1883, leading to underground rail transportation of coal.

Earliest full mechanization began in the 1920's when loading machines were successfully utilized in a number of mines. Rubber-tired shuttle cars were introduced in the 1930's, leading to rapid conversion of track-mounted loaders and cutters to off-track types. After World War II, tungsten carbide bits were introduced, thereby greatly improving the performance of cutting machines; continuous mining machines started making inroads in 1948; and roof bolting (installation of long bolts to stabilize the mine roof) became feasible, a significant development that resulted in higher productivity and increased safety. Although longwall mining has been used extensively in Europe since the early 1900's, this technique became increasingly important in the United States only after the development of hydraulic, self-propelled roof jacks. The growth and history of certain facets of the U.S. bituminous coal mining industry can be seen in Table IV-7 and Figures IV-5 through IV-11.

Transportation

Transportation costs are often a significant part of the overall cost of mining coal, especially if long distances are involved. For example, the rail cost of shipping coal from Gillette, Wyoming to Houston, Texas, a distance of 1,700 miles, is $15.60 per short ton, whereas the f.o.b. mine value is only $6.50 per short ton. (12). Locks and dams were built on a number of rivers beginning about 1845, leading to a considerable increase in the development of river transportation. Trucking of coal has become more important over the last 30 years if relatively short distances are involved, even though the cost per ton-mile is generally higher than for other means of shipment. It is practical where railroad facilities do not exist or where rail cannot be economically justified. High-tonnage conveyor systems are also used to move coal from mine to plant in certain situations.

Railroads have remained competitive by changing to unit-train shipments of coal. The unit train system moves approximately 9,000 metric tons (10,000 short tons) of coal directly from mine to customer and features high loading and unloading rates.

The effort to ship coal more economically from mine to powerplant resulted in the successful operation of the first coal pipeline for over six years (after which, in this case, rail transportation became more economical due to unit-train shipment), moving 1.13 million metric tons (1.25 million short tons) of Ohio coal annually over a distance of 100 miles. A more recently constructed coal slurry pipeline is operating in Arizona and is designed to transport 5.0 million metric tons (5.5 million short tons) annually from mine to a powerplant over a distance of 273 miles.

The development of very high-voltage electrical transmission lines has provided another option for moving large quantities of energy to consumer areas from mine-based generating stations. Figure IV-12 illustrates U.S. coal transportation by method of movement, 1976 and projected.

LOCATION AND PRODUCTION

Present

Table IV-7 (Part 1 of 3)

GROWTH OF THE BITUMINOUS AND LIGNITE COAL MINING INDUSTRY IN THE UNITED STATES

Year	Total Production (kkg ÷ 10^6)
1800	0.1
1900	181.4
1910	453.6
1920	515.9
1925	471.8
1930	424.1
1935	337.8
1940	418.0
1945	524.0
1950	468.4
1955	421.5
1960	376.9
1965	464.6
1966	484.3
1967	501.3
1968	494.6
1969	508.5
1970	547.0
1971	500.9
1972	540.1
1973	536.1
1974	547.4
1975	588.3
1976	615.7
1977	627.2
1978	593.1
1979	770.0*
1983	804.7
1985	905.0
1990	1,088.6[5]

Table IV-7 (Part 2 of 3)

GROWTH OF THE BITUMINOUS AND LIGNITE COAL MINING INDUSTRY IN THE UNITED STATES

Year	Value ($ + 10^6)	Average Price f.o.b. Mines ($/kkg)[a]	Number of Mines	Production Surface Methods (kkg + 10^6)	Production Surface Methods (%)	Production Underground Methods (kkg + 10^6)	Production Underground Methods (%)	Underground Production: Mined by Continuous Mining Machines (%)	Underground Production: Mechanically Loaded (%)	Average Number of Employees Working Daily: Total	Productivity (kkg/man-day)[a]: Total
1920	2,130	4.13	8,921	7.5	1.5	508.2	98.5			639,547	3.63
1925	1,060	2.25	7,144	15.1	3.2	456.7	96.8		1.2	588,493	4.10
1930	795	1.87	5,891	18.2	4.3	405.9	95.7		10.5	493,202	4.59
1935	658	1.95	6,315	21.6	6.4	316.2	93.6		13.5	462,403	4.08
1940	879	2.11	6,324	39.3	9.4	378.7	90.6		35.4	439,075	4.71
1945	1,768	3.37	7,033	99.6	19.0	424.4	81.0		56.1	383,100	5.24
1950	2,500	5.34	9,429	111.9	23.9	356.5	76.1	1.2	69.4	415,582	6.14
1955	2,092	4.96	7,856	104.5	24.8	317.0	73.9	8.0	84.6	225,093	8.93
1960	1,950	5.17	7,865	111.2	29.5	265.7	68.6	27.4	86.3	169,400	11.64
1965	2,276	4.89	7,228	150.1	32.3	314.5	64.9	42.7	89.2	133,732	15.89
1966	2,421	5.00	6,749	163.2	33.7	321.1	63.4	45.8	91.7	131,752	16.80
1967	2,555	5.09	5,873	169.9	33.9	331.4	63.1	47.4[b]	94.5	131,523	17.39
1968	2,546	5.15	5,327	168.7	34.1	325.9	63.1	47.6[b]	95.7	127,894	17.57
1969	2,796	5.50	5,118	179.0	35.2	329.5	61.9	49.7[b]	96.6	124,532	18.05
1970	3,773	6.90	5,601	221.5	40.5	325.5	56.2	50.1[b]	97.2	140,140	17.09
1971	3,905	7.79	5,149	234.9	46.9	266.0	50.0	55.4[b]	98.2	145,664	16.35
1972	4,562	8.44	4,879	250.1	46.3	290.0	51.1	58.7[b]	99.0	149,265	16.09
1973	4,976	9.28	4,650	249.8	46.6	286.3	51.0	na	99.2	157,800	15.20
1974	9,502	17.36	5,247	295.6	54.0	251.8	46.0			166,701	15.94
1975	12,472	21.20	6,168	322.4	54.8	265.9	45.2			189,880	13.37
1976	13,189	21.42	6,161	348.5	56.6	267.2	43.4			202,280	13.12
1977	13,709	21.86	6,200	387.0	61.7	240.2	38.3			214,777	13.37
1978	14,645	24.69	6,075	373.1	62.9	220.0	37.1			221,000	12.94

Table IV-7 (Part 3 of 3)

GROWTH OF THE BITUMINOUS AND LIGNITE COAL MINING INDUSTRY IN THE UNITED STATES

Footnotes:

(1) Multiply by 1.1023 to obtain short (English) tons ÷ 10^6.

(2) Multiply by 0.9072 to obtain $/short ton.

(3) Multiply by 0.9072 to obtain short tons/man-day.

(4) Mined by longwall machines; 1967, 0.9%; 1968, 1.3%; 1969, 1.8%; 1970, 2.1%; 1971, 2.4%; 1972, 2.6%; 1978, 5% (90 longwalls).

(5) NCA estimates that the national goal of 1.1 billion metric tons (1.2 billion short tons) annual coal production by 1985 will not be achieved until 1990.

* Estimated

Note: 1 kkg = 1,000 kilograms = 1 metric ton

Sources:	Years 1800, 1900, 1910:	(1)
	Years 1920 - 1978:	(13)
	Years 1979, 1983, 1990:	(14), (estimated by NCA)
	Year 1985:	U.S. Bureau of Mines

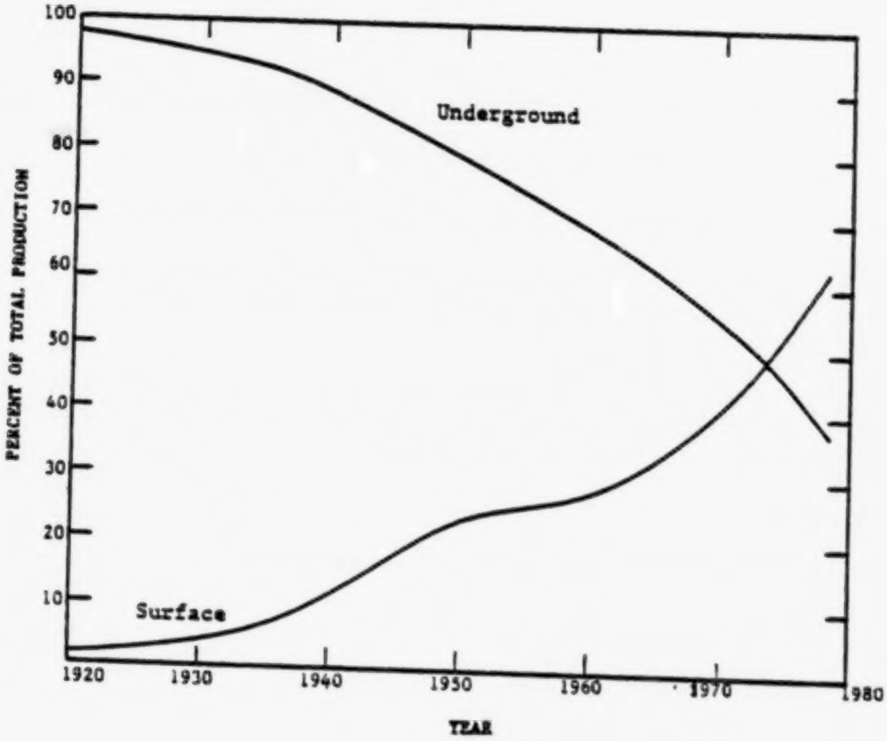


Figure IV- 5
PRODUCTION: SURFACE METHODS VERSUS
UNDERGROUND METHODS

Source: 1979 Keystone Coal Industry Data

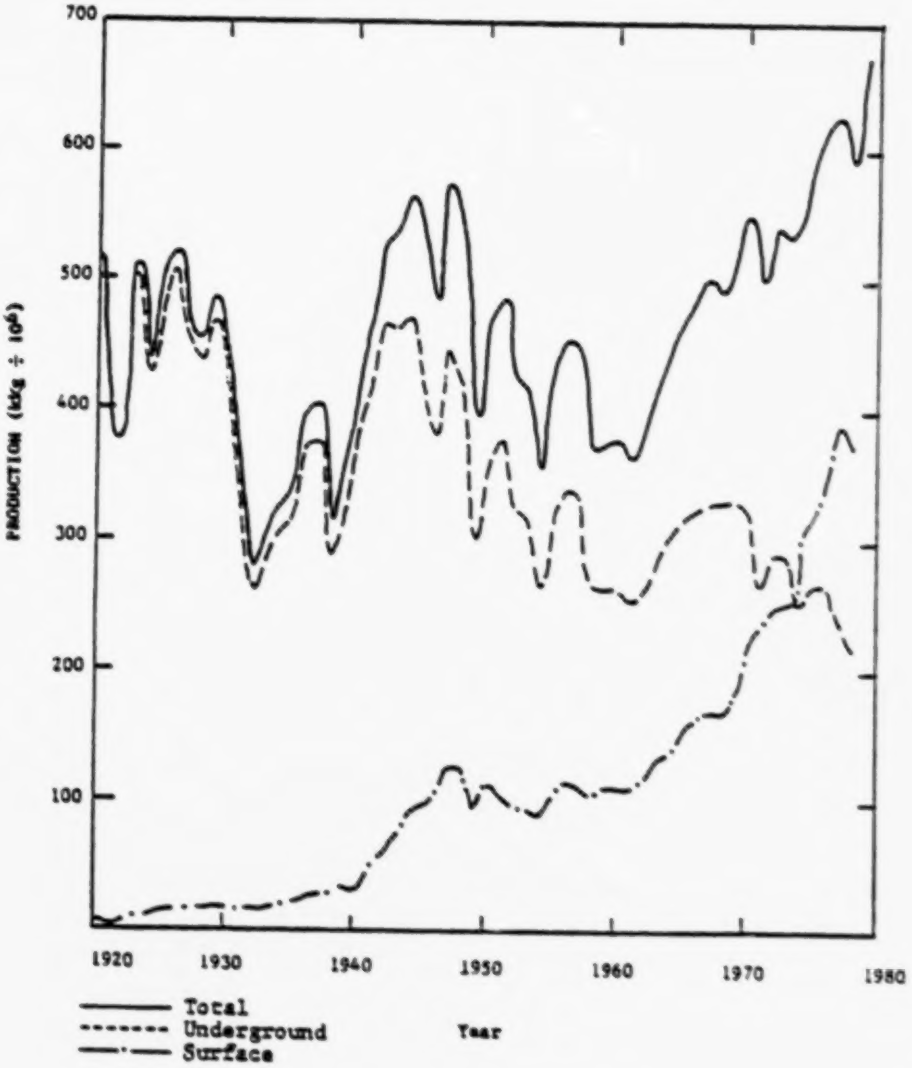


Figure IV- 6
HISTORY OF BITUMINOUS AND LIGNITE
COAL PRODUCTION

Source: 1979 Keystone Coal Industry Data

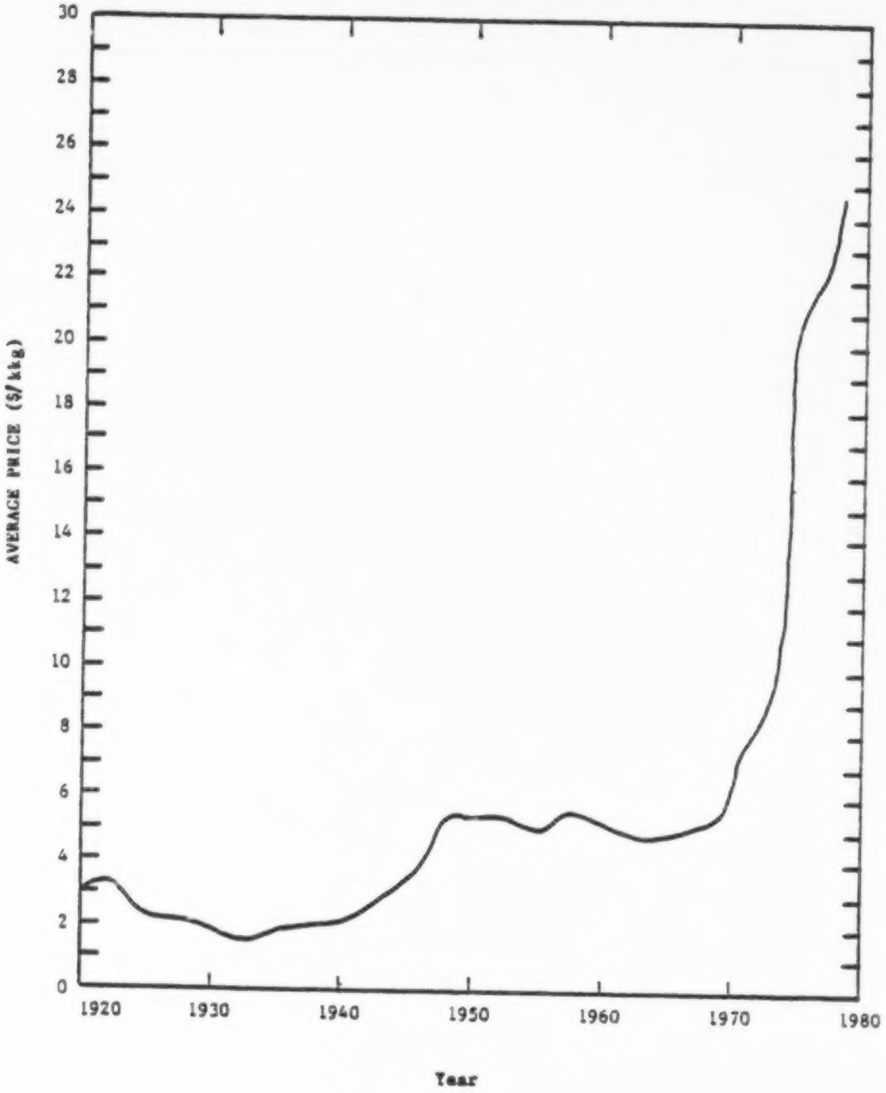


Figure IV-7
HISTORY OF COAL PRICES
(f.o.b. Mines)

Source: 1979 Keystone Coal Industry Data

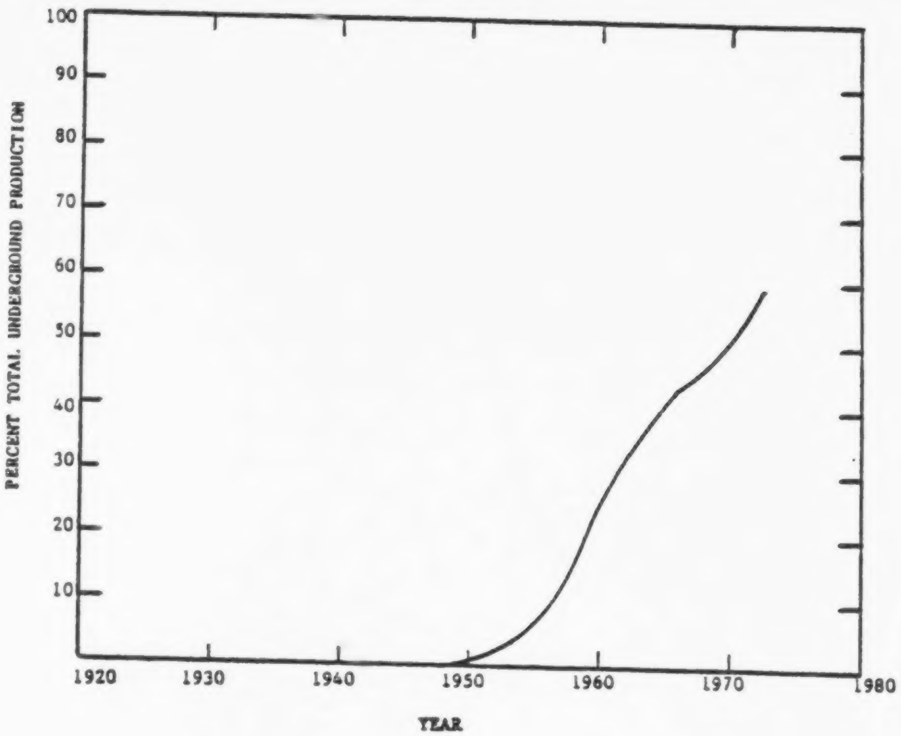


Figure IV-8

HISTORY OF UNDERGROUND COAL MINED BY CONTINUOUS MINING MACHINES

Source: 1979 Keystone Coal Industry Data

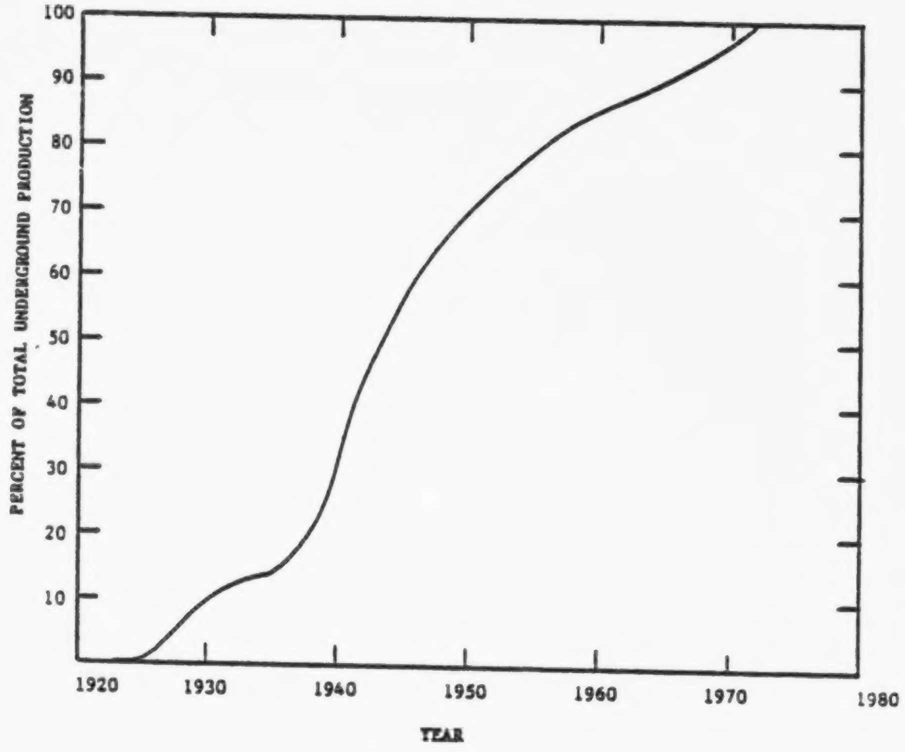


Figure IV-9
HISTORY OF UNDERGROUND COAL - MECHANICALLY LOADED

Source: 1979 Keystone Coal Industry Data

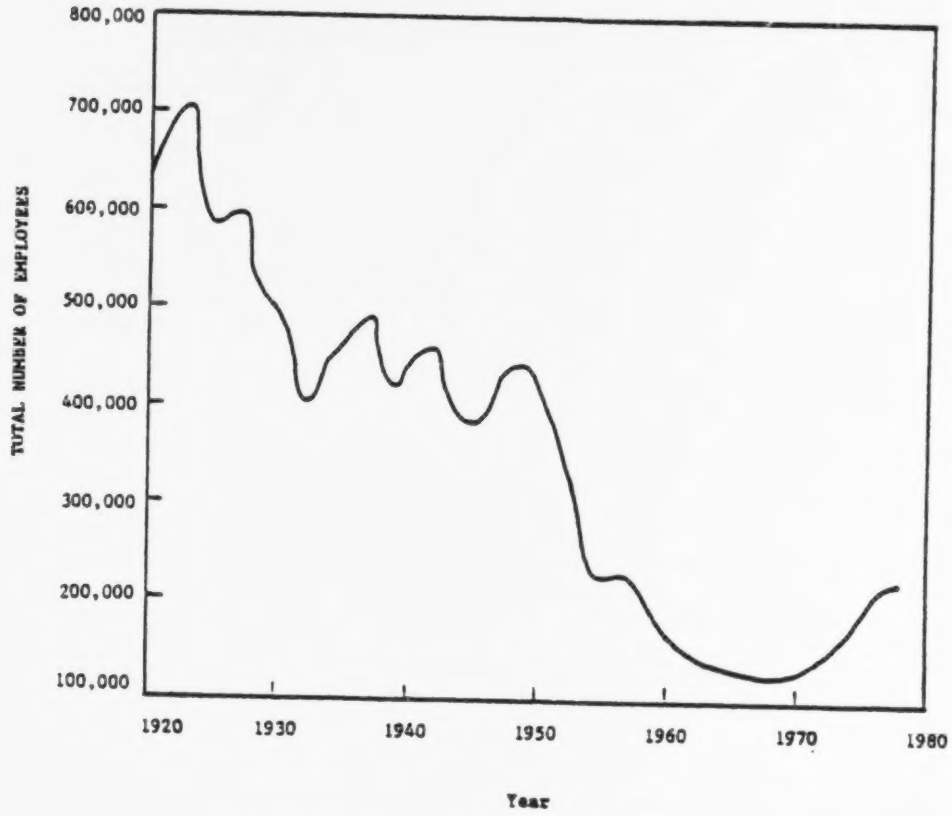


Figure IV-10
HISTORY OF NUMBER OF EMPLOYEES

Source: 1979 Keystone Coal Industry Data

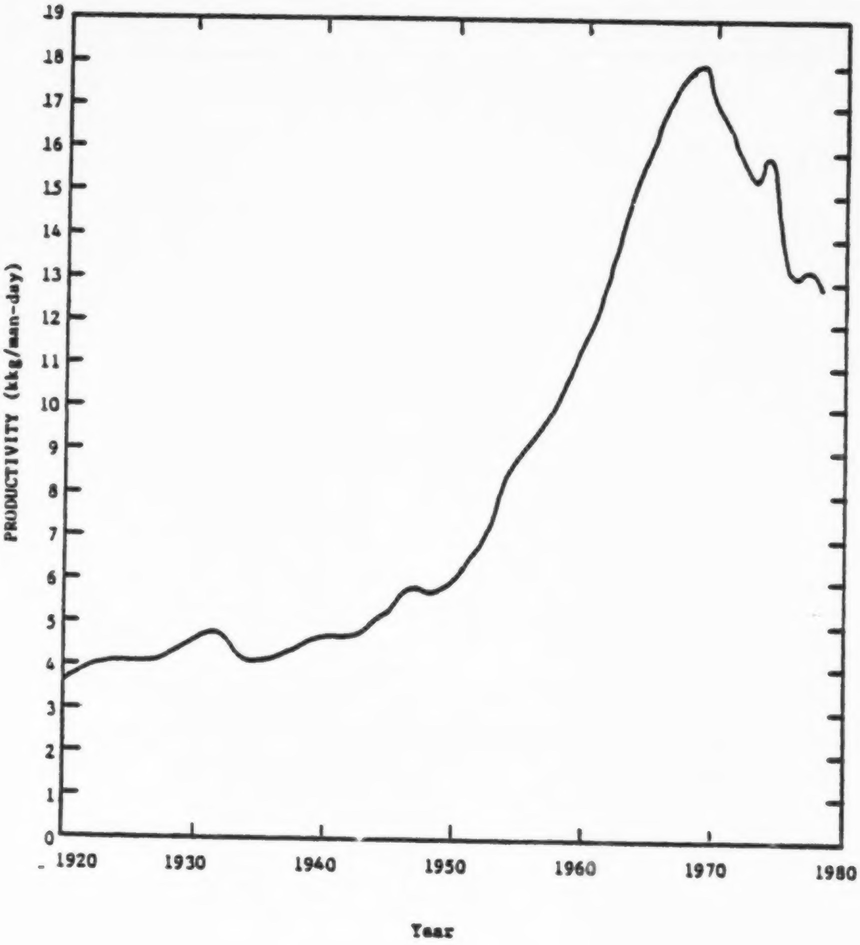
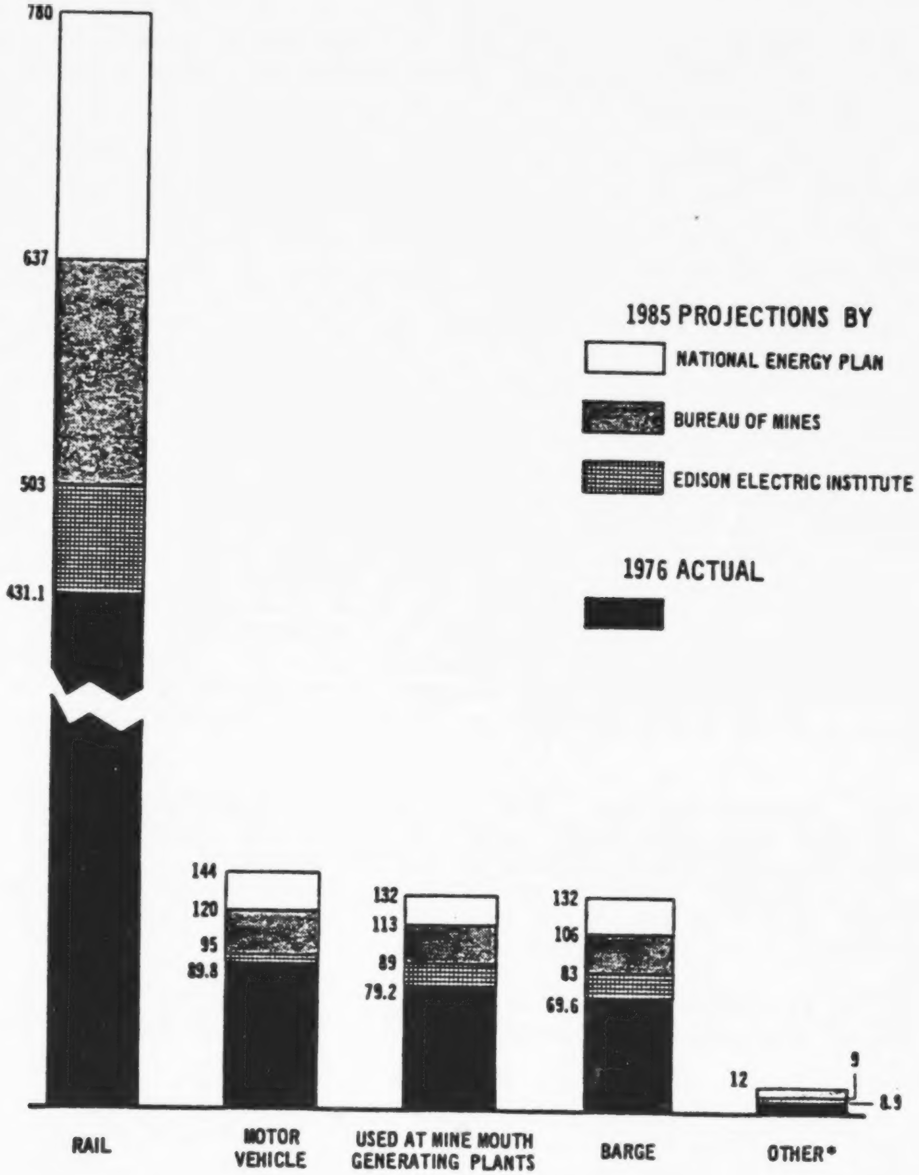


Figure IV-11
HISTORY OF PRODUCTIVITY RATES

Source: 1979 Keystone Coal Industry Data



* Coal Slurry Pipeline or Used at Mine

Figure IV-12

U.S. COAL TRANSPORTATION BY METHOD OF MOVEMENT, 1976 AND PROJECTED (million tons)

Source: (15)

The U.S. bituminous coal production in 1980 was a record 823.6 million tons (13). The National Coal Association forcasts that this year's (1982) output will be 880 million tons.

The coal industry currently operates in 26 states; mines are located in Appalachia, the Midwest, and Mountain and Pacific regions. The geographical distribution of coal mines by state and type of mining is illustrated in Figure IV-13. Table IV-8 lists the 1981 annual coal production for all 26 states. Mines east of the Mississippi River accounted for about 66 percent of 1981 production, whereas mines west of the Mississippi River accounted for 33 percent of production. In recent years western production has increased and it is estimated that western coal will account for about 37% of total U.S. production by 1989.

Most underground coal mines in the U.S. are located east of the Mississippi although there are some in the west, particularly in Utah and Colorado. Fifty years ago, when most coal mining was done by manual labor, underground mines accounted for 96% of all coal produced in the U.S. each year. This has slowly changed over the years such that today 60% of coal production is from surface mines. Half of the surface mineable coal is in the west but significant amounts are also present in Appalachia and midwestern states. Table IV-9 shows the changes in distribution of both eastern and western coal mines and underground and surface coal mines that have occurred over the past 10 years.

Bituminous, subbituminous, and lignite deposits comprise over 99 percent of the nation's total coal reserves, as estimated by the U.S. Geological Survey (17). Deposits are widespread, occuring in several major coal-producing regions across the United States. Figure IV-14 illustrates the location of major bituminous, subbituminous, and lignite deposits in the United States.

Figure IV-15 illustrates the location of the major anthracite coal fields which are primarily located in northeastern Pennsylvania.

Future

Coal production from mines currently being developed, from older mines being expanded, or from those operations in planning stages, could add about 515 million tons of new capacity to the nation's total by the end of 1989.(15) That conclusion is drawn from a recenty completed industry-wide survey conducted by Keystone Coal Industry Manual.

This survey accounts for 324 expanding or planned mines projecting a combined output, including present production, of 780 million tpy of bituminous coal and lignite. This figure does not include production from mines now operating that will not expand during the 1980-1989 period and the 39.7 million tons scheduled for development after 1989.

Of the 324 new mines, 157 were in some stage of operation before 1980 with a production level of 188.24 million tpy to that date. Those

Table IV-8

1981 U.S. Coal Production, By State

(Thousand Short Tons)

State	Underground	Surface	Total	% of Total U.S.
1. Kentucky	81,000	68,068	149,068	18.3
2. West Virginia	89,568	23,228	112,814	13.8
3. Wyoming	1,093	101,622	102,715	12.6
4. Pennsylvania	34,650	46,150	80,800	9.9
5. Illinois	29,236	22,484	51,720	6.3
6. Virginia	36,450	9,050	45,500	5.6
7. Ohio	9,950	27,408	37,358	4.6
8. Montana	---	33,380	33,380	4.1
9. Texas	---	32,892	32,892	4.0
10. Indiana	557	28,807	29,364	3.6
11. Alabama	9,260	15,627	24,887	3.1
12. Colorado	6,606	12,925	19,531	2.4
13. New Mexico	791	18,125	18,916	2.3
14. North Dakota	---	17,995	17,995	2.2
15. Utah	13,809	---	13,809	1.7
16. Arizona	---	11,614	11,614	1.4
17. Tennessee	5,250	5,350	10,600	1.3
18. Oklahoma	---	5,250	5,250	0.6
19. Washington	---	4,810	4,810	0.6
20. Missouri	---	4,715	4,715	0.6
21. Maryland	1,903	2,550	4,453	0.5
22. Alaska	---	800	800	*
23. Kansas	---	785	785	*
24. Iowa	70	585	655	*
25. Arkansas	---	280	280	*
26. Georgia	---	5	5	*
TOTAL U.S.	320,211	494,505	814,716	100.0

*less than 0.1 percent

Source: Ref. (13).

Table IV-9

Coal Production by Region and Type of Mine, 1971-81

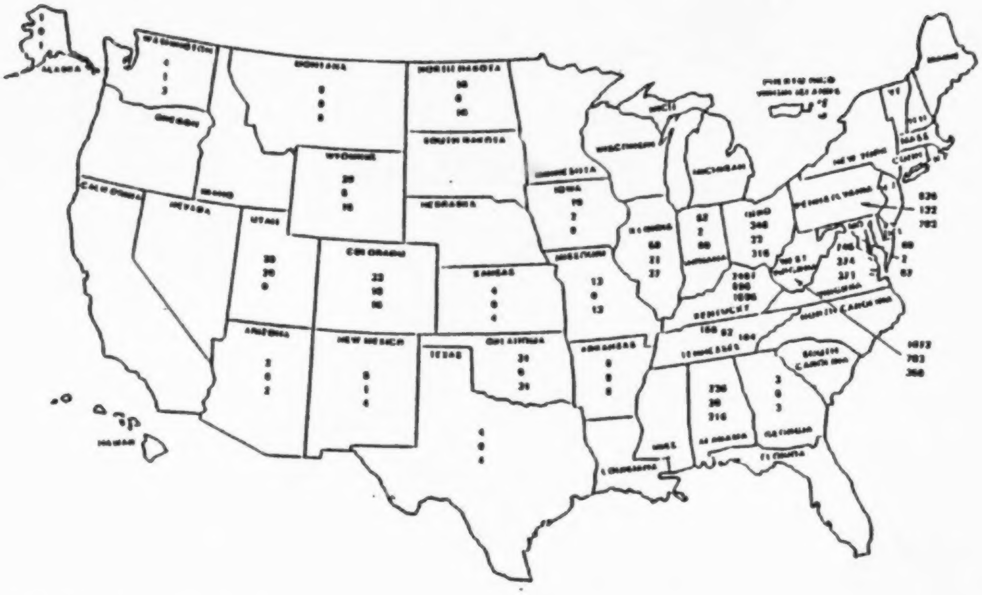
(Thousand Short Tons)

Year	Total Production	East	West	Under-Ground	Surface
1971*	552,192	483,880	50,980	275,887	258,973
1972	595,386	515,496	64,338	304,102	275,732
1973	591,738	515,303	76,435	299,353	292,385
1974*	603,406	511,501	91,906	277,309	326,097
1975	648,438	537,503	110,934	292,826	355,612
1976	678,685	542,604	136,081	294,880	383,805
1977	691,344	527,406	163,938	265,950	425,394
1978*	665,127	482,141	182,986	242,117	422,950
1979	776,299	550,552	222,941	320,321	455,978
1980	823,644	572,632	251,012	336,925	486,719
1981*p	814,716	546,569	268,147	320,211	494,505

*Coal strike years

p = preliminary

Source: Ref. (13).



Sequential Listing Indicates:

Total Number of Mines
Total Number of Underground Mines
Total Number of Surface Mines (Includes Strip, Auger and Strip - Auger Mines)

Figure IV-13
GEOGRAPHICAL DISTRIBUTION OF COAL MINES

Source: (19)

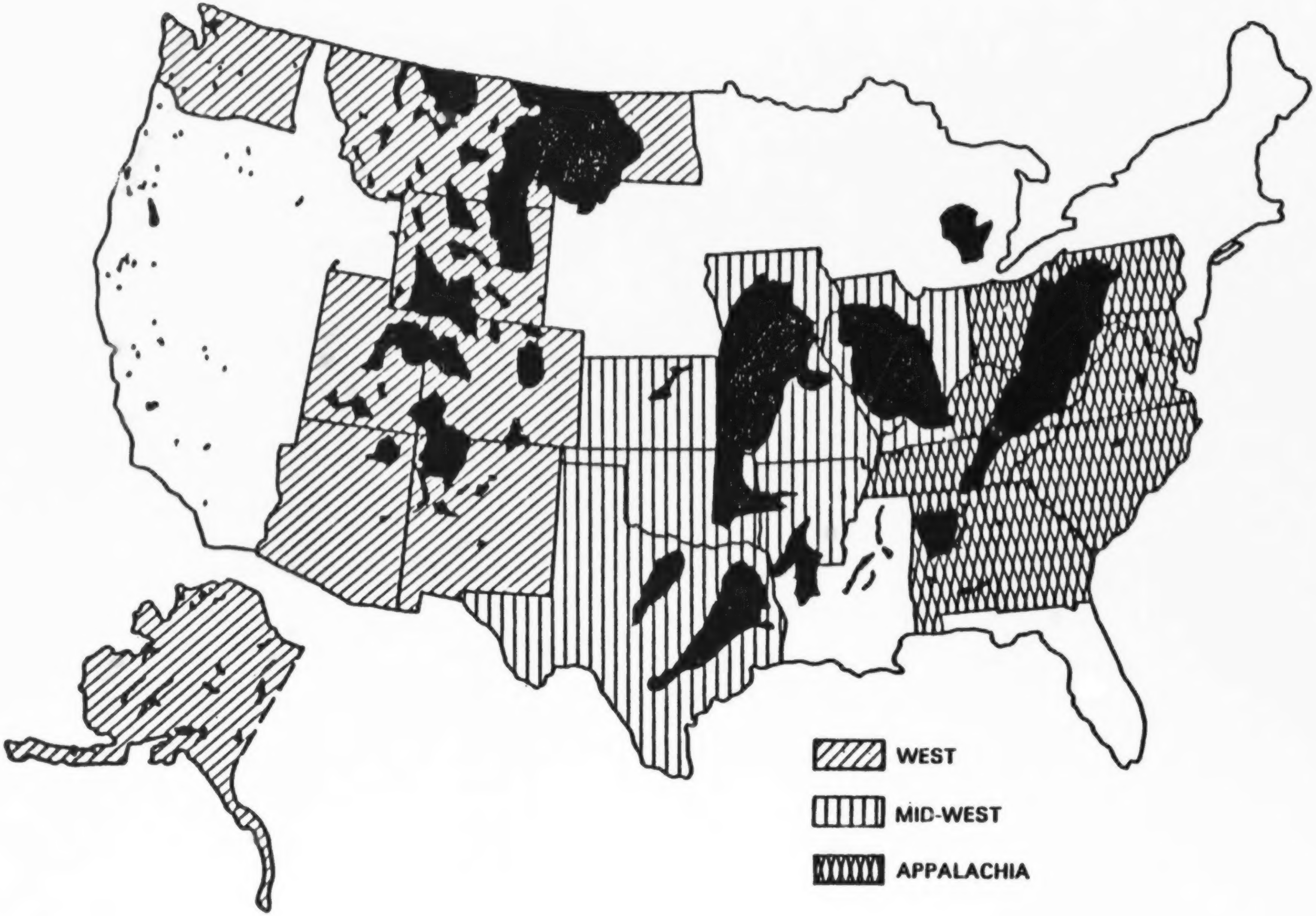


Figure IV-14

MAJOR BITUMINOUS, SUBBITUMINOUS AND LIGNITE COAL DEPOSITS IN THE UNITED STATES

Source: (16)

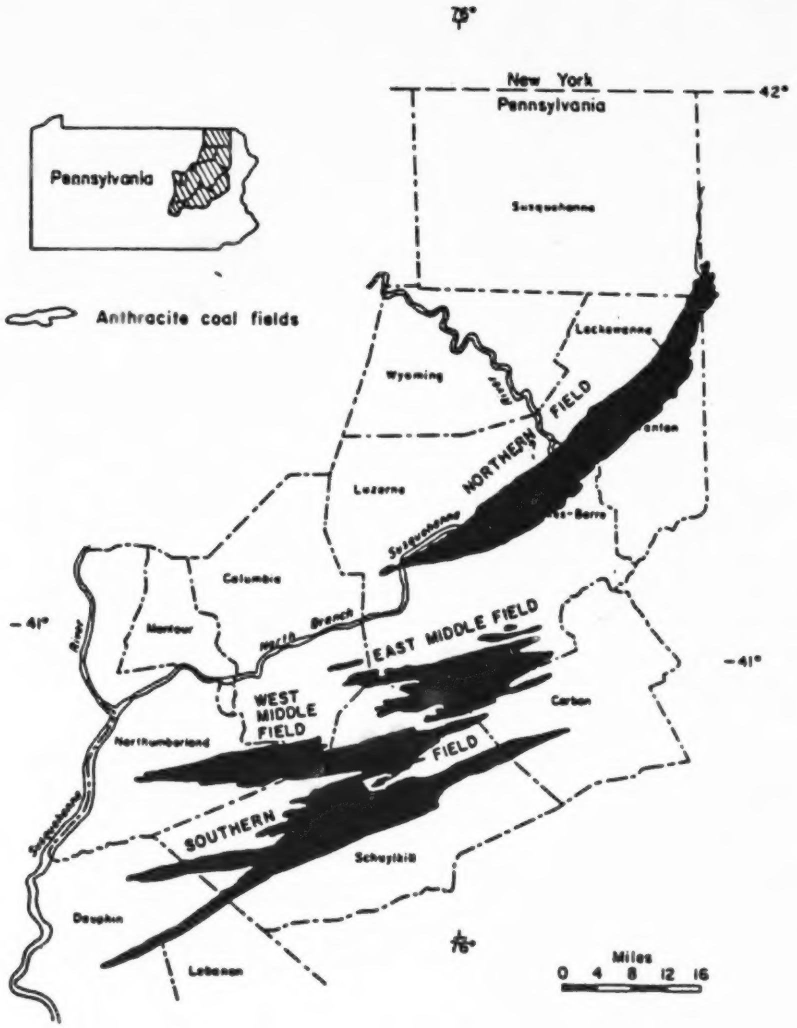


Figure IV- 15

LOCATION OF THE MAJOR ANTHRACITE COAL FIELDS IN THE U.S.
NORTHEASTERN PENNSYLVANIA

Source: (11)

same mines added 62.16 million more tons during 1980. In addition, 39 mines that opened in 1980 have a combined output of 14.15 million tpy at this stage of their development.

Again, the majority of new mines reported will be underground operations, but as before, surface mining will account for the larger share of production. Of the 324 mines, 148 will be surface operations. They will produce 607.10 million tpy, or 74% of total anticipated production capacity of these mines. The other 176 underground mines will have a combined output capacity of 212.63 million tpy. Seven of the operations will produce by both surface and underground methods, and will produce 11.5 million tpy.

Most of the new capacity will be from operations west of the Mississippi River where 156 mines will produce 616.03 million tpy, or about 75% of the total. Wyoming developments lead the field with 35 mines showing a projected total capacity of 269.85 million tpy in 1989. Montana also projects a sizable increase of 76.60 million tons to be produced from 11 mines. Texas, North Dakota and New Mexico follow with projected output of 66.55, 48.50 and 47.00 million tpy, respectively.

The primary use for the output of these new mines is for steam coal purposes, with 92% devoted to that goal. Metallurgical grade coal is expected to comprise only about 8% of the total. The surveyed mines have the capacity to produce 750.25 million tpy of steam coal in all. Of that amount 163.41 million tons of capacity were already on line by 1980. An additional 64.14 million tons of capacity were added last year, indicating steam capacity to be added by 1989 or later will be about 522.7 milliom tpy.

Metallurgical grade coal mines should have the capacity to produce 69.48 million tpy by 1989 or later, of which 32.49 million tpy will be new capacity. The developing mines already in production before 1980 had reached 24.83 million tpy of production capacity, and another 12.16 million tpy were added last year.

The companies involved with the expansion program were the producers of about 66% of total U.S. output of 776 million tons in 1979.

MINING METHODS

Surface Mining

Surface mining is employed where the coal is close enough to the surface to enable the overburden (the soil and rock above the coal) to be removed economically and later replaced or regraded. Types of equipment used to remove overburden at mines in the United States include draglines, bucket wheel excavators, old generation stripping shovels, cable shovels and trucks, hydraulic shovels and trucks, front-end loaders and trucks, scraper-dozer units, and dozers assisting either front-end loaders, hydraulic shovels, or cable shovels. There are two general types of surface mines--contour mines and area mines.

Contour Mining

Contour mining prevails in mountainous and hilly terrain such as Appalachia. For instance, if a coal seam is visualized as lying level at an elevation of 1,000 feet above sea level, and the land surface elevation varies from 600 to 1,400 feet above sea level, a contour stripping situation exists. Mining commences where the coal and surface elevations are the same, commonly called the cropline, and proceeds around the side of the hill on the cropline elevation. The earth overlying the coal (overburden) may be removed by shovel, dragline, scraper, or bulldozer, depending on the depth and type of overburden encountered. The overburden is removed and the coal is loaded into trucks and removed from the pit. A second cut or pit can then be excavated by placing the overburden from it back into the first cut or pit. Succeeding cuts, if any, would follow in the same sequence, with the amount of overburden increasing on each succeeding cut until the economic limit of the operation, or the maximum depth limit of the overburden machine (i.e., dragline or stripping shovel), is reached.

In the preceding description, only a single-level seam operation has been considered. There are many situations where several seams of coal may exist and they may pitch at various angles from the horizontal, as is fairly common in West Virginia and Pennsylvania. Although the mining of multiple or pitching seams is more complicated, the principle of contour stripping remains the same--finding where the surface and coal elevations are the same and following this contour until the economic limit is reached. Several types of contour mining practices exist. The primary distinction in most of these procedures is the method of spoil disposal.

Spoil Deposited Over Side of Hill. This practice has been virtually eliminated by the Federal Surface Mining Control and Reclamation Act of 1977 (SMCRA), which prohibits the placing of materials on the downslope in steep mining situations (i.e., Appalachian area, on slopes 20 degrees or greater). In past practices, this was the easiest way to get rid of overburden from the first cut in a hillside, by casting it over the side onto the downslope. Overburden from the second cut was then placed into the mined-out first cut and so on until the economic limit of the operation was reached. The highwall left at the end of mining often remained essentially unreclaimed, except the coal seam was generally covered up; methods sometimes varied according to state law. SMCRA requires that highwalls be reclaimed, thereby eliminating this practice. Also, the practice of spoiling on the downslope has been replaced by techniques whereby spoil from the first cut or pit(s) is placed in hollow fills, or is stockpiled, hauled, conveyed, or pushed into a mined-out pit (or any combination of these techniques).

Because of the significantly increased costs of producing coal by contour mining (partially as a result of eliminating certain practices), many such operations have been eliminated or replaced by mountain-top or finger-ridge mining techniques. Figure IV-16 illustrates the contour mining method when spoil is deposited over the side of the hill.

Spoil Deposited in Hollow Fills. This method employs placement of spoil from initial cuts into approved hollow fills. Hollow fill design criteria varies from state to state. Figure IV-17 portrays a West Virginia hollow fill.

Haulback Mining. Truck haulback has become a successful technique for surface mining coal throughout the Appalachian regions. The haulback method, as the name implies, involves haulage of spoil laterally back along the bench, where it is placed on the pit floor. However, spoil from initial pits is either stockpiled or placed in hollow fills. This method offers many advantages environmentally and helps coal operators to comply with two significant provisions of SMCRA: (1) the requirement that surface-mined land be returned to the approximate original contour, and (2) the requirement that no spoil be pushed over the mining bench onto the slopes below. There are some reclamation advantages as well. Haulback permits the surface-mined area to be back-filled and seeded on a continuous cycle, sharing the same production schedule as the coal or stripping functions. This permits revegetating the slopes while the soil is still pliable and auxiliary equipment is still around. Furthermore, the haulback method also cuts down by approximately two-thirds the amount of disturbed lands at any given time. However, the logistics of timing the blasting, stripping, mining, and hauling sequences in the truck haulback method can become complicated. This mining technique is now widely used in eastern Kentucky, southern West Virginia, and northern Tennessee. Figure IV-18 illustrates the haulback mining technique.

Auger Mining. When the economic limit is reached in normal surface mining operations, the coal seam remains exposed at the bottom of the final highwall. This coal can be partially recovered by one of three methods: conventional underground mining, punch mining (a series of entries into a seam by a continuous miner), or auger mining (spiral boring for additional recovery of a coal seam exposed in a highwall). Auger mining is usually applied to contour operations but can also be utilized in area type mining. Some mines, especially in Kentucky, use the auger method only. The coal seams are augered from specially prepared narrow benches, some only about 20 feet wide, and from a low highwall that is scarcely more than the thickness of the coal seam. Records show that coal recovery by augering is quite low, usually less than 35 percent, and penetration generally is only about 150 feet. Unless properly planned, such mining can shut off large blocks of future deep coal by making the reserve very expensive to reach. As

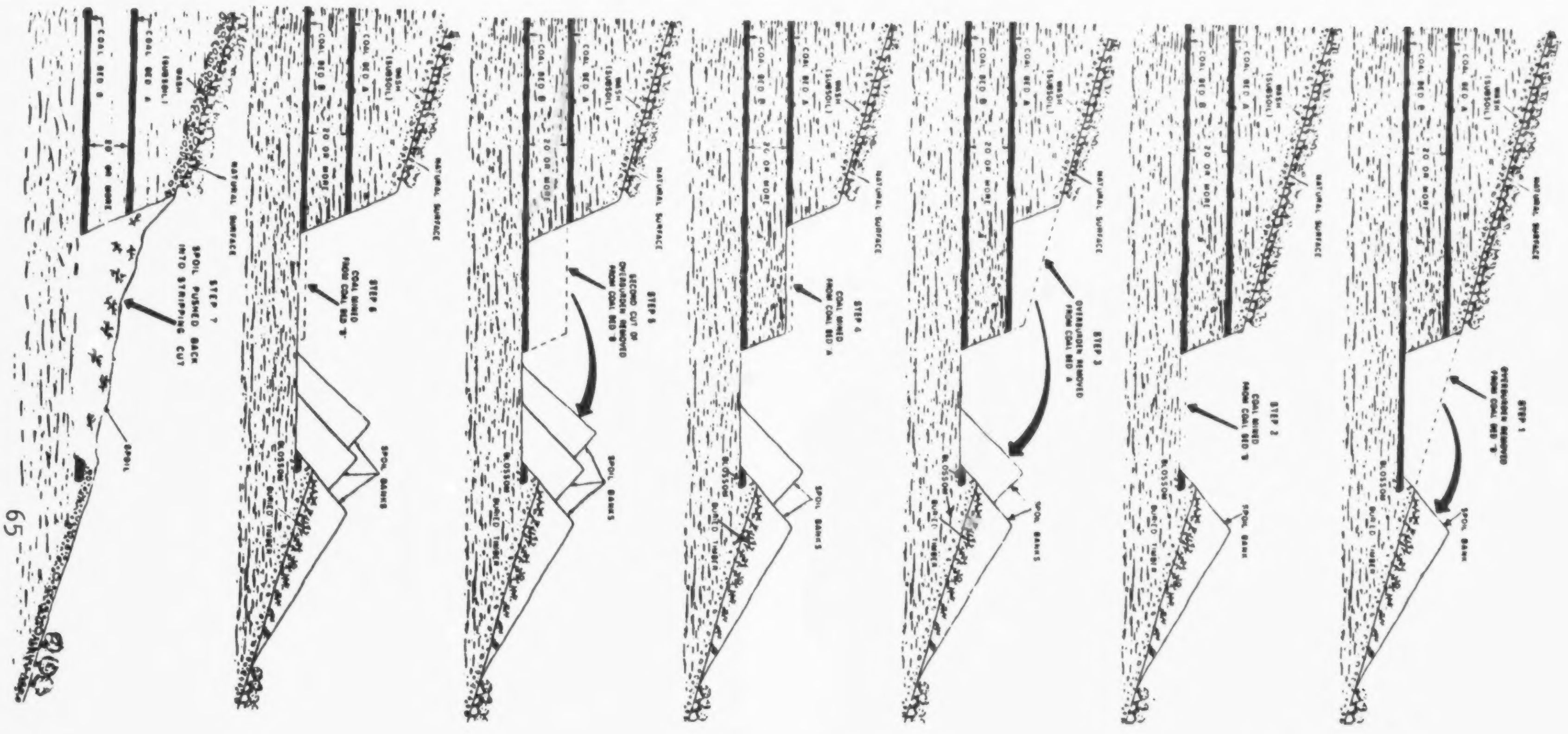

NATURAL SURFACE
WASH (SUBSOIL)
COAL BED A
COAL BED B
20' OR MORE
STEP 1
OVERBURDEN REMOVED FROM COAL BED "B"
SPOIL BANK
BLOSSOM
BURIED TIMBER
STEP 2
COAL MINED FROM COAL BED "B"
STEP 3
OVERBURDEN REMOVED FROM COAL BED A
SPOIL BANKS
STEP 4
COAL MINED FROM COAL BED A
STEP 5
SECOND CUT OF OVERBURDEN REMOVED FROM COAL BED "B"
STEP 6
COAL MINED FROM COAL BED "B"
STEP 7
SPOIL PUSHED BACK INTO STRIPPING CUT
SPOIL

Figure IV-16

CONTOUR MINING (STRIPPING)
(Spoil Deposited Over Side of Hill)

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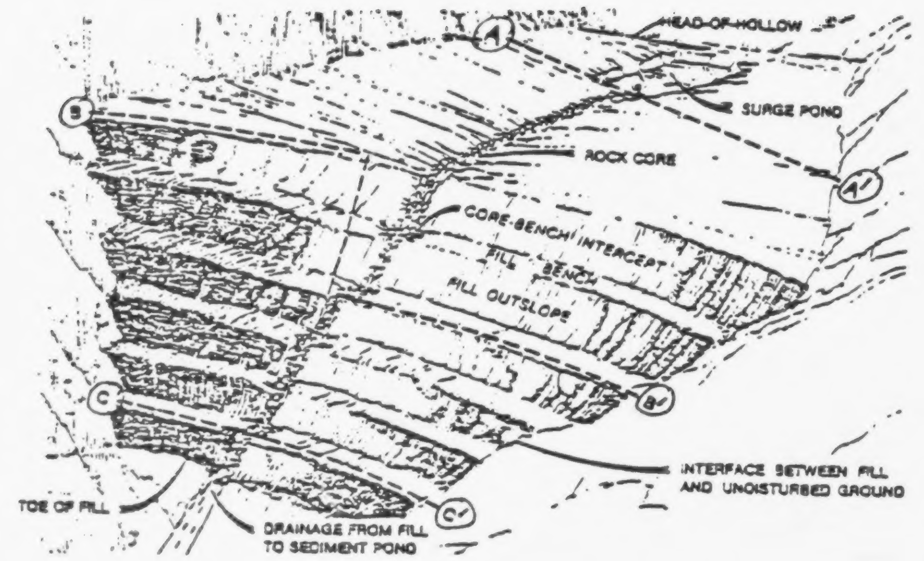
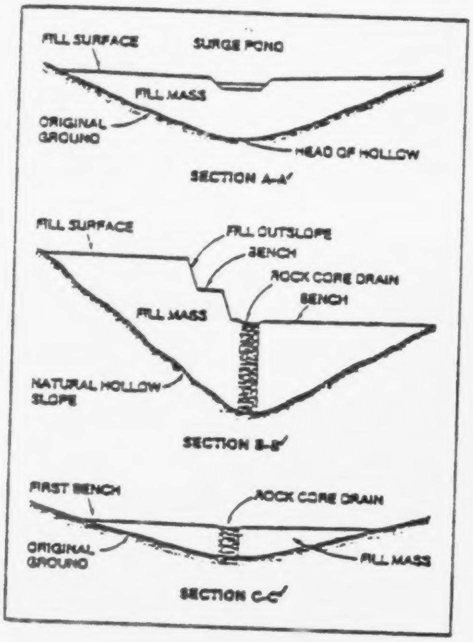
Source: U.S. Bureau of Mines.





West Virginia present head-of-hollow criteria (far left) requires that all water enter a surge pond and rock core to drain down through center of fill (left). Example of this type of construction is the fill (above) built at Buffalo Mining Co.'s Gopher mine.

Figure IV-17

WEST VIRGINIA HOLLOW FILL

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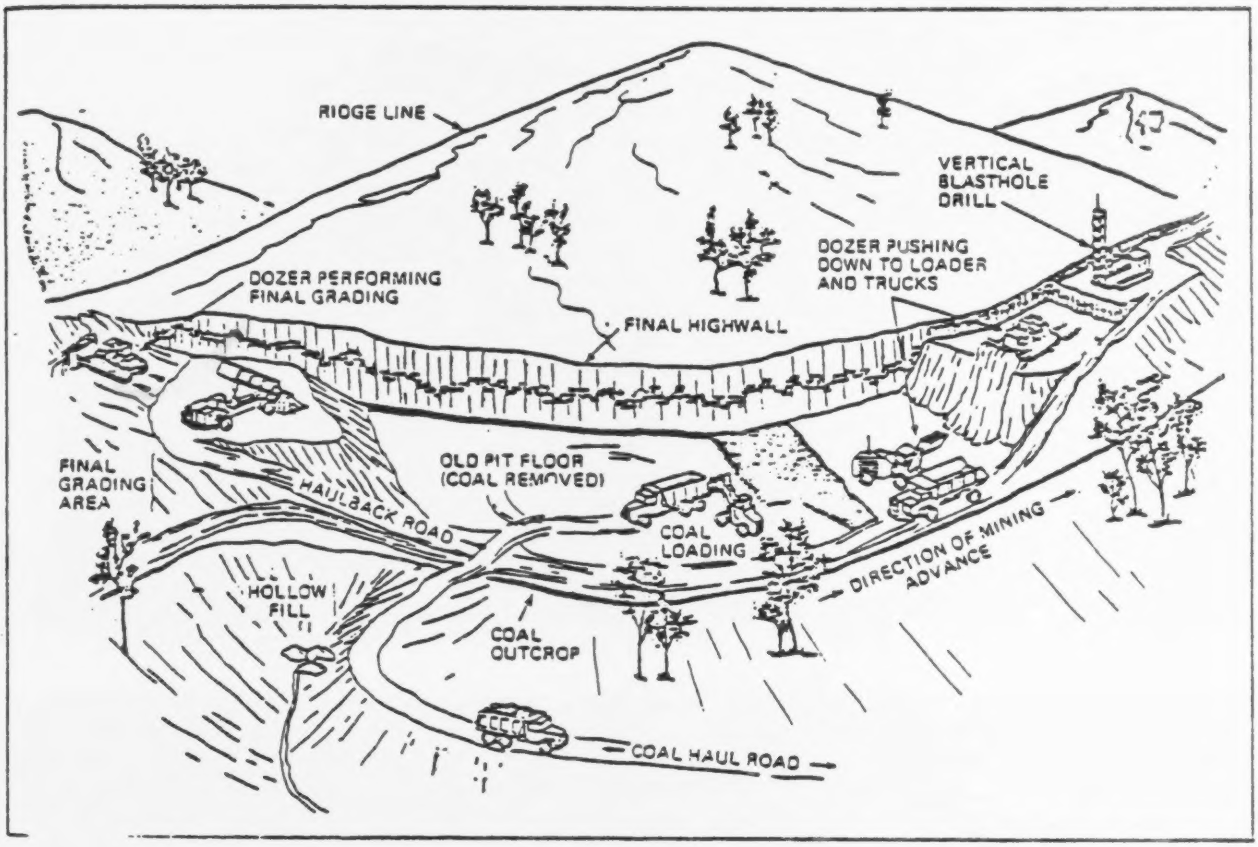

(Single-seam haulback operation in Appalachia involves three integrated phases of overburden removal, coal loading, and reclamation.)

Figure IV-18

HAULBACK MINING

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low as the coal recovery is from auger mining, there are conditions where it is warranted as it is low-cost production and frequently makes it possible to mine coal reserves that are thin, dirty, isolated, and not economically recoverable by any other means. Auger mining accounts for about 2.5 percent of total U.S. coal production.

Area Mining

Strip Mining. In some regions of the United States, especially in the West and Midwest, many of the economically significant coal seams lie in a relatively level plane beneath a flat to gently rolling surface terrain. Consequently, the depth of the coal below the surface will remain fairly constant over extensive areas. This type of deposit can ordinarily be developed by conventional dragline or shovel methods using "area type" surface mining; that is, excavation of a sequence of parallel pits which may extend several thousand feet in length. Mining by the conventional "area" method normally begins at the cropline where the overburden is shallow. Spoil from the initial cut (box cut) is placed on virgin ground. The overburden from each succeeding pit is then spoiled into the previous pit where the coal has been removed. Reclamation operations follow closely behind the advancing mining front. The final highwall and entire mine area is reclaimed back to approximate original contour. In addition to draglines or conventional shovels, stripping can also be performed by bucket-wheel excavators, shovels and trucks, endloaders and trucks, or scrapers. The trucks and scrapers haul overburden around the end of the pit, depositing it in the mined- out strip-cuts or other spoil storage sites. Figure IV-19 illustrates area mining with draglines. Figure IV-20 illustrates area mining with a stripping shovel.

Open-Pit Mining. Some western area type mines utilizing shovels and trucks, endloaders and trucks, or scrapers develop open-pit mine configurations whereby overburden and coal are removed in blocks rather than strip-cuts. Overburden from initial pits is normally placed off the area to be mined, often in depression areas, sometimes on previously mined areas, then overburden from succeeding pits is placed back into pits where the coal has been removed. Figure IV-21 portrays open-pit mining of a thick seam.

Other New Surface Mining Methods

Mountaintop Mining. In recent years, several mining techniques have been developed which minimize the adverse effects of mining on steep slopes. Because of new strip mine laws and reclamation requirements, these techniques have often replaced or eliminated the practice of contour mining. The new methods include mountaintop (or hilltop) mining and finger-ridge mining. Figure IV-22 depicts the cross-ridge concept of mountaintop mining. The mountaintop mining method involves removal of the entire hilltop or mountaintop above a coal seam or multiple coal seams. Most of the overburden is usually placed in hollow fills, while some overburden is retained for final reclamation of the "tabletop" landscape left upon termination of mining. A new mountaintop technique, called cross-ridge mining, mines across the

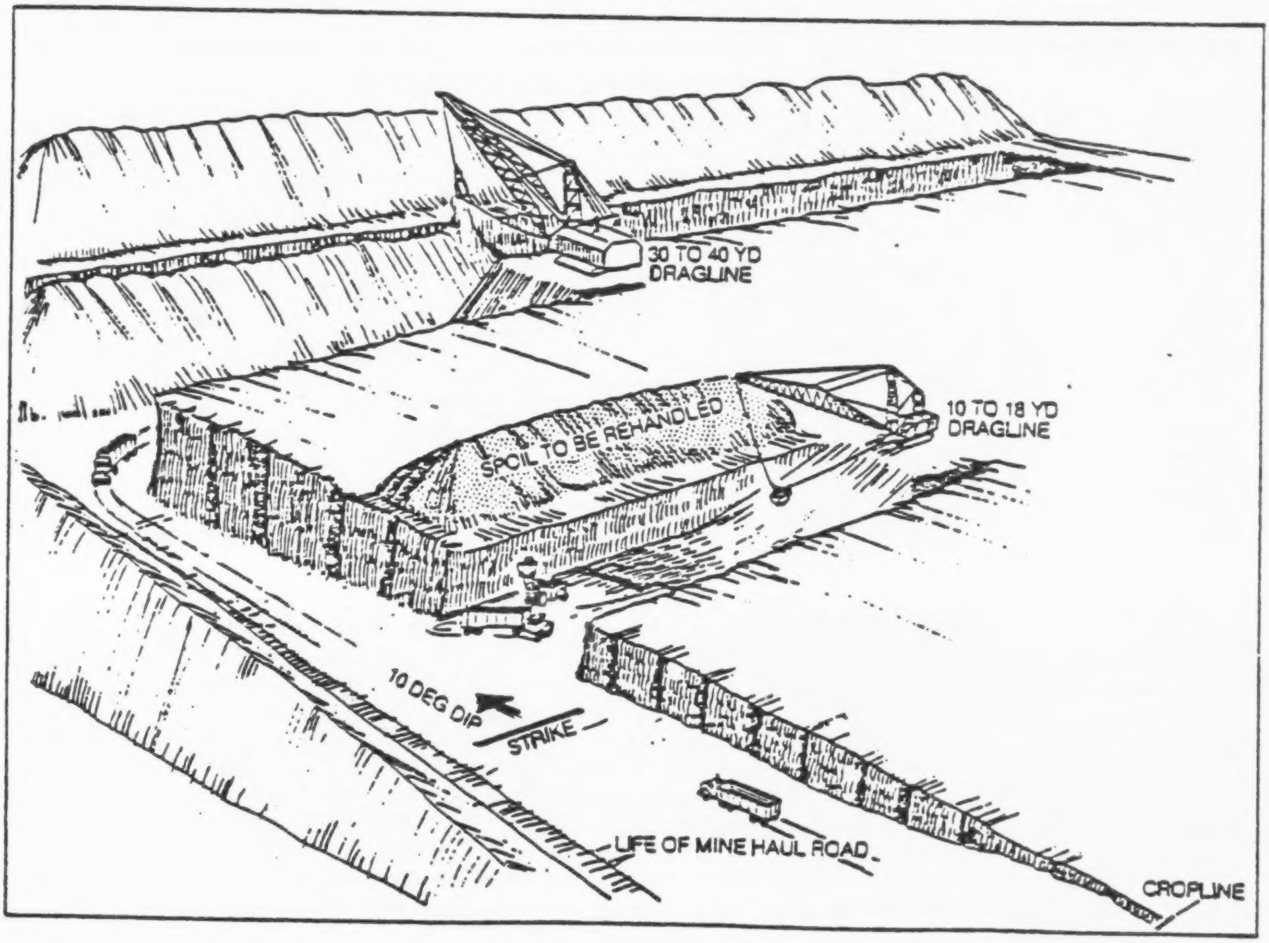

Figure IV-19

AREA MINING WITH DRAGLINES

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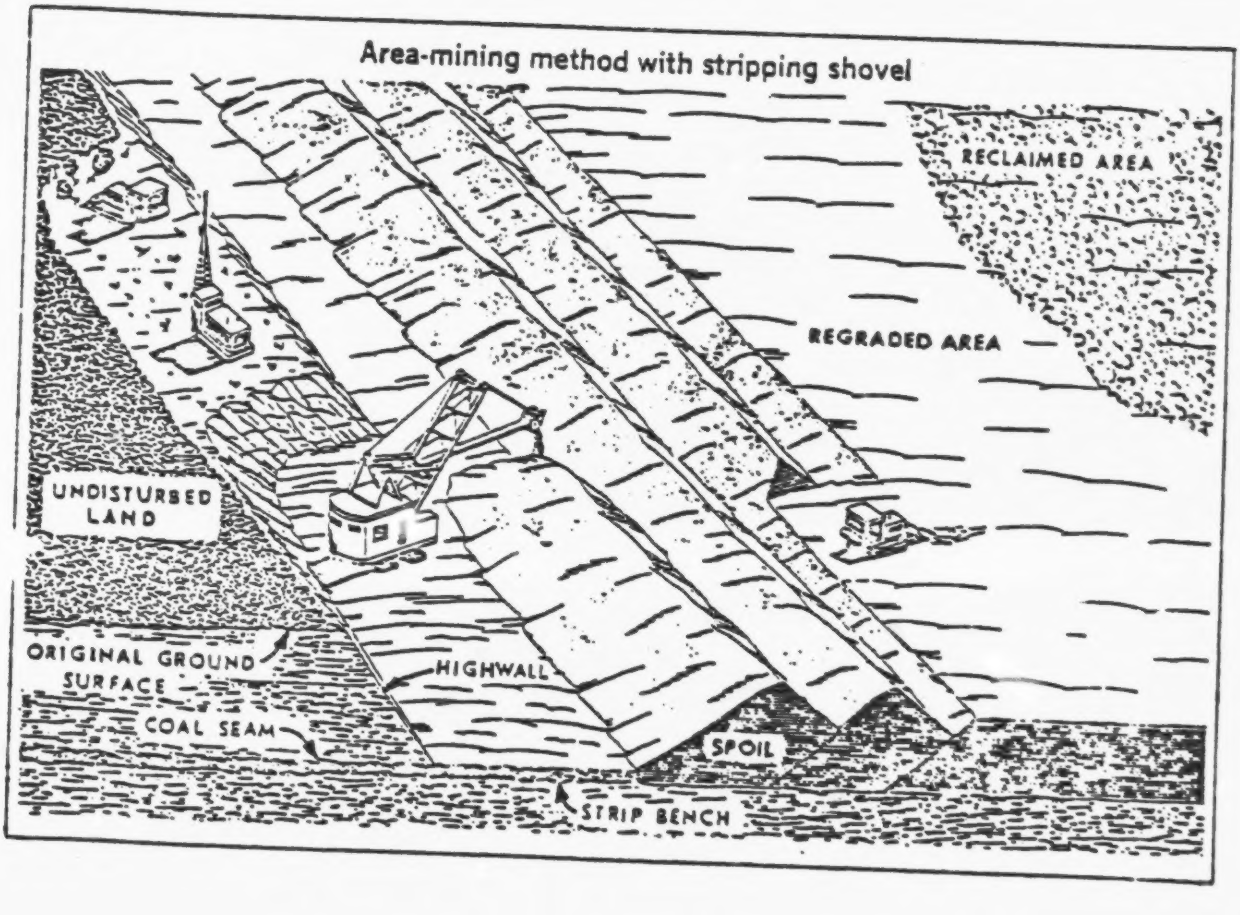

Figure IV-20

AREA MINING WITH STRIPPING SHOVEL

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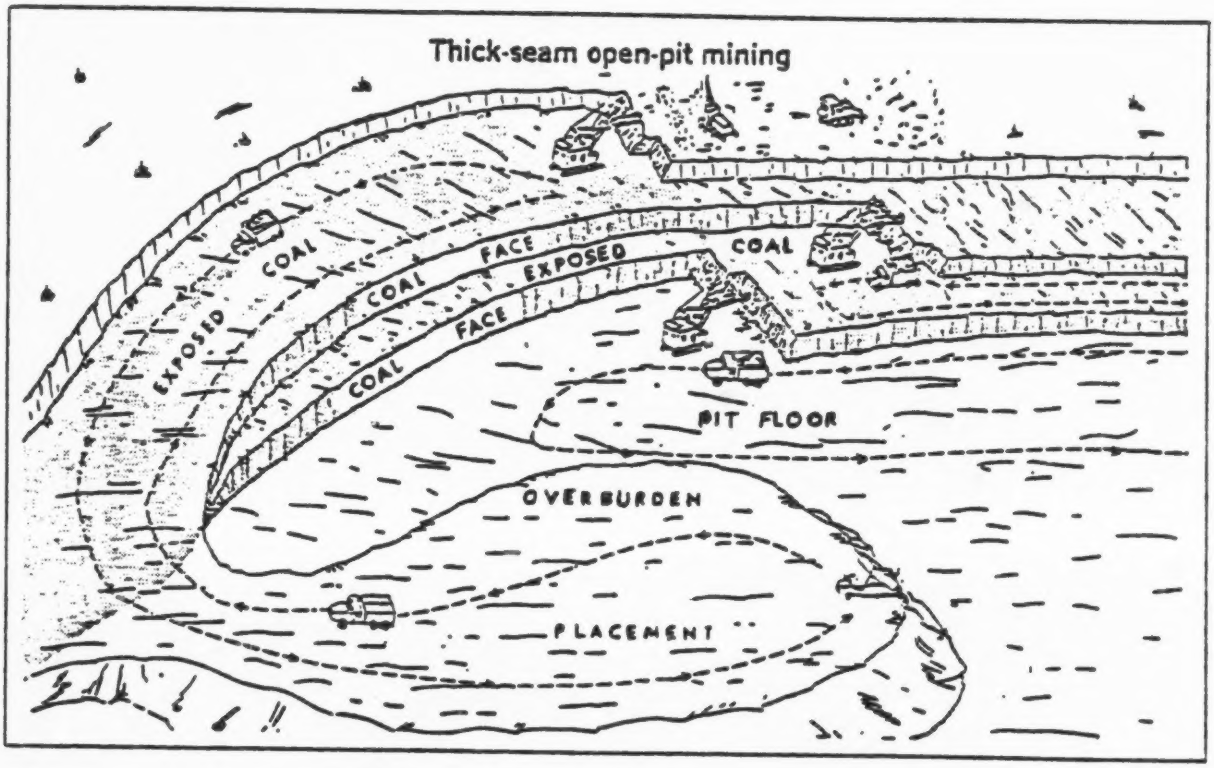

Figure IV- 21

AREA MINING (OPEN-PIT MINING) OF A THICK SEAM

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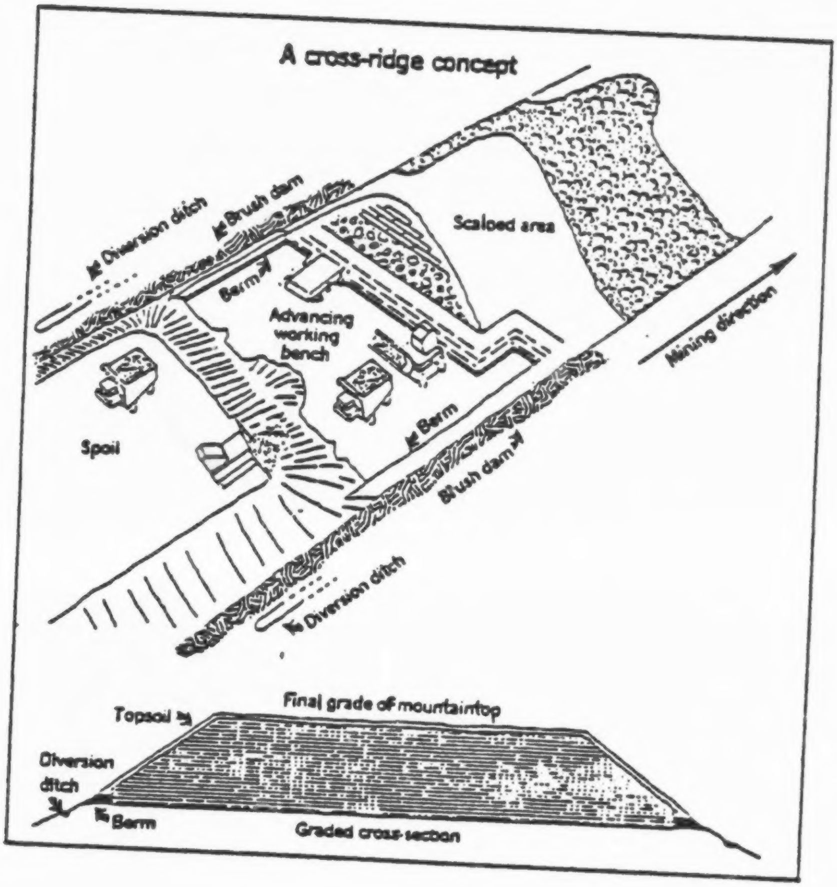

Figure IV- 22

AREA MINING
(CROSS-RIDGE MOUNTAINTOP METHOD)

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ridges between the coal outcrops and places more spoil on top of the mined out area. This technique reduces the required volume of hollow fill areas.

Finger-Ridge Mining. Finger-ridge removal methods can also utilize cross-ridge mining techniques. Finger-ridge mining is similar to mountaintop mining; however, instead of removing the entire mountain or hill above the coal seam(s), only the ridges or incremental parts of the mountain above the coal seam(s) are removed. This allows operators to take advantage of lower stripping ratios in ridge areas. The final highwall, which often represents economic cutoff, occurs where the strip ratio becomes too high as mining progresses into the mountain. The block of coal that remains could be mined later if economic conditions become favorable or new techniques are developed.

Underground Mining

Underground methods are employed where the coal is too deep to be surface mined economically or environmental restrictions preclude surface mining. Basically, there are three types of underground mines according to the manner in which the opening from the surface to the coal seam is made. These include drift mines, slope mines, and shaft mines (see Figure IV-23). In a drift mine, the opening into the coal is horizontal or made directly into the seam at a point where it outcrops on the surface. A slope mine uses an inclined opening to reach the coal. A slope entry is usually employed where the coal seam is at an intermediate depth (there is no visible outcrop), or where the coal outcrop condition is unsatisfactory or unsafe for drift entry. Shaft mines are usually developed when the coal seam lies deep underground.

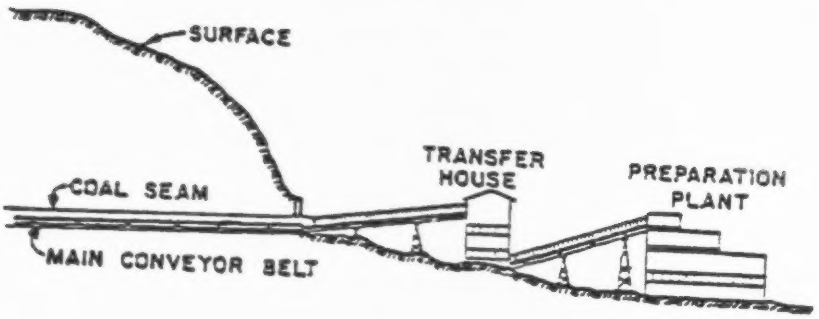
Conventional

This method extracts the coal in a sequence of operations, with special equipment to execute each step. First, the coal is cut by a cutting machine and then drilled, loaded with explosives, and blasted. The broken coal is gathered by a loading machine and transported to a shuttle car (or in some cases, the coal is both gathered and transported by specially designed equipment), which dumps the coal onto a conveyor belt or a mine car loadout station. A machine follows closely behind the operating face installing roof bolts, or other roof support items such as timbers or steel crossbars. This type of mining system is gradually being phased out in the United States and is being replaced by continuous mining machines. Figure IV-24 illustrates room and pillar mining by conventional methods.

Continuous

This method utilizes a single machine called a "continuous miner" which breaks the coal mechanically, then loads and transports it to a shuttle car. The shuttle car transports the coal to a conveyor belt for passage out of the mine. A roof bolting machine is usually scheduled to follow closely behind the operating face. Recently,

DRIFT MINE



SLOPE MINE

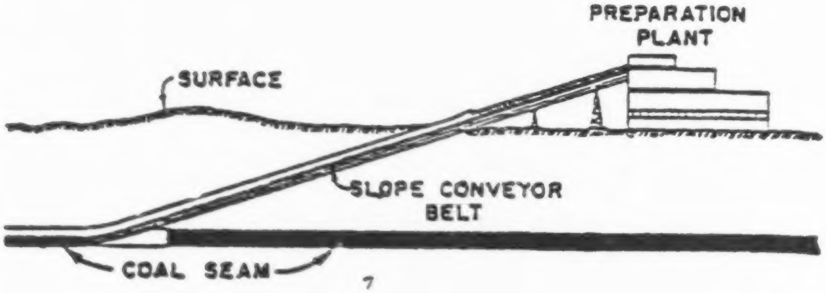


Figure IV- 23

UNDERGROUND MINING PRACTICES

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SHAFT MINE

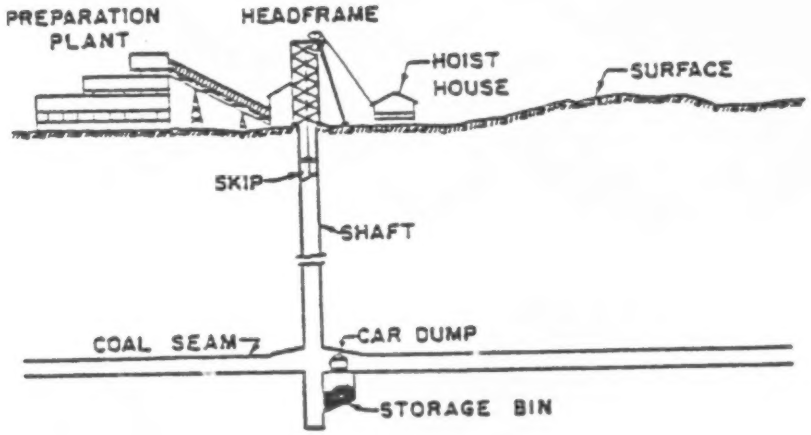

Figure IV-23 (Continued)
UNDERGROUND MINING PRACTICES

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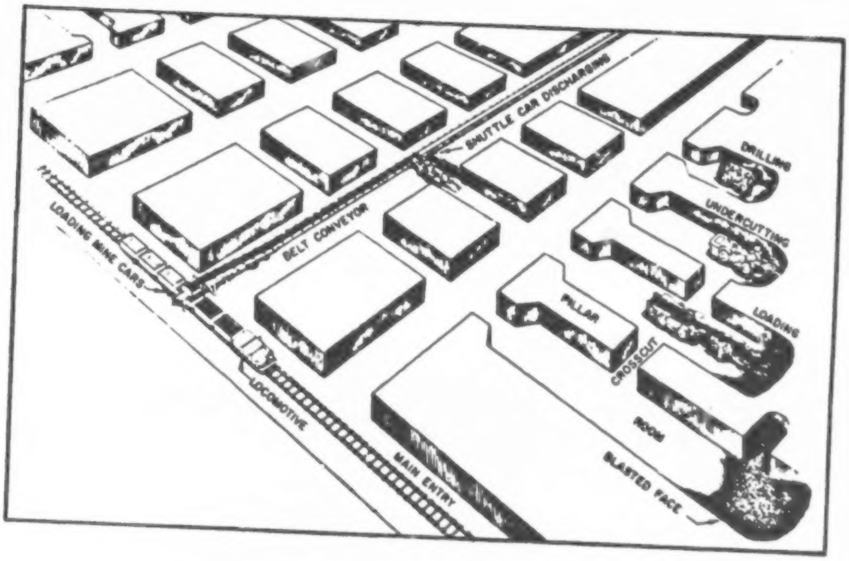

Figure IV-24

UNDERGROUND COAL MINING - ROOM-AND-PILLAR SYSTEM
(Conventional Method)

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Source: U.S. Bureau of Mines

development towards continuous haulage has been emphasized whereby the conveyor belt system connects directly to the continuous miner; also, mounting roof bolting equipment on continuous miners has been explored. These developments are likely to further improve productivity and safety. Both the conventional and continuous mining methods use the room and pillar technique to extract the coal. Main tunnels, or headings, are first driven from the point of entry into the coal seam. From these main headings, secondary headings are driven perpendicularly. Blocks of coal are then extracted in a systematic pattern along both sides of the headings, and pillars of intact coal are left between the mined-out rooms to support the mine roof and prevent surface subsidence above the workings. Once a given area or entire mine property has been developed, retreat mining is often practiced in which additional coal is mined from the pillars, thereby increasing overall coal recovery. Room and pillar mining normally achieves extraction of 40 to 60 percent of the coal seam.

Longwall

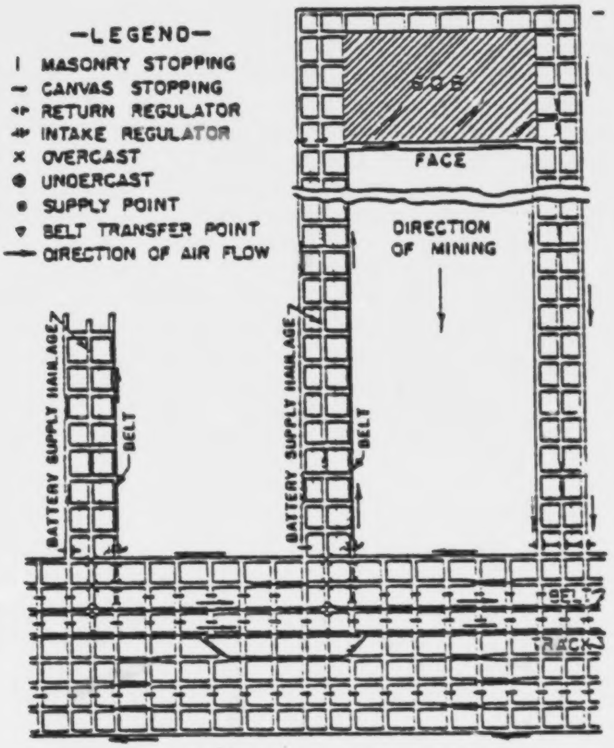
Longwall mining is relatively new to the mining industry. This system mines large blocks of coal, outlined during the mine development phase, which are completely extracted in a single, continuous operation. Longwall mining machines utilize coal cutters that move across a section of the face and the cut coal falls onto a continuously moving face conveyor. Hydraulic roof supports are advanced with each pass of the cutter, permitting controlled roof collapse as mining progresses. Longwall mining, once properly implemented, is usually highly productive and allows increased recovery of the coal since it is unnecessary to leave pillars of coal for roof support as in other mining methods. One quarter of western deep mines currently use longwalls. Longwall mining techniques are illustrated in Figure IV-25.

Shortwall

This new mining method, introduced from Australian mines, represents a combination of the continuous mining and longwall systems. Either continuous mining equipment or conventional equipment is used to develop the field. A continuous miner, in conjunction with the longwall-type roof supports, is then used to extract the remaining coal pillars. The individual pillars or blocks of coal are somewhat smaller than those in longwall operations. Transportation of the coal may be by shuttle cars or by newly developed portable, flexible belt conveyors that follow the continuous miner in and out (i.e., continuous haulage). As in longwall mining, shortwall mining also offers improved coal recovery. Shortwall mining techniques are illustrated in Figure IV-26.

PREPARATION PLANTS AND ASSOCIATED AREAS

UNDERGROUND MINING PLAN FOR LONGWALL DEVELOPMENT MINERS



PLAN OF THE LONGWALL FACE THAT IS SHOWN ABOVE

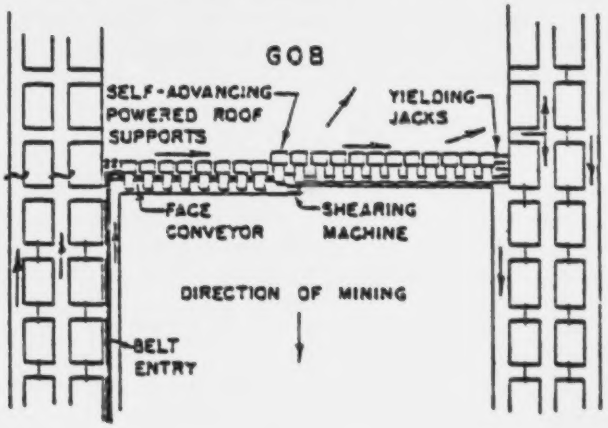


Figure IV- 25

LONGWALL MINING METHOD

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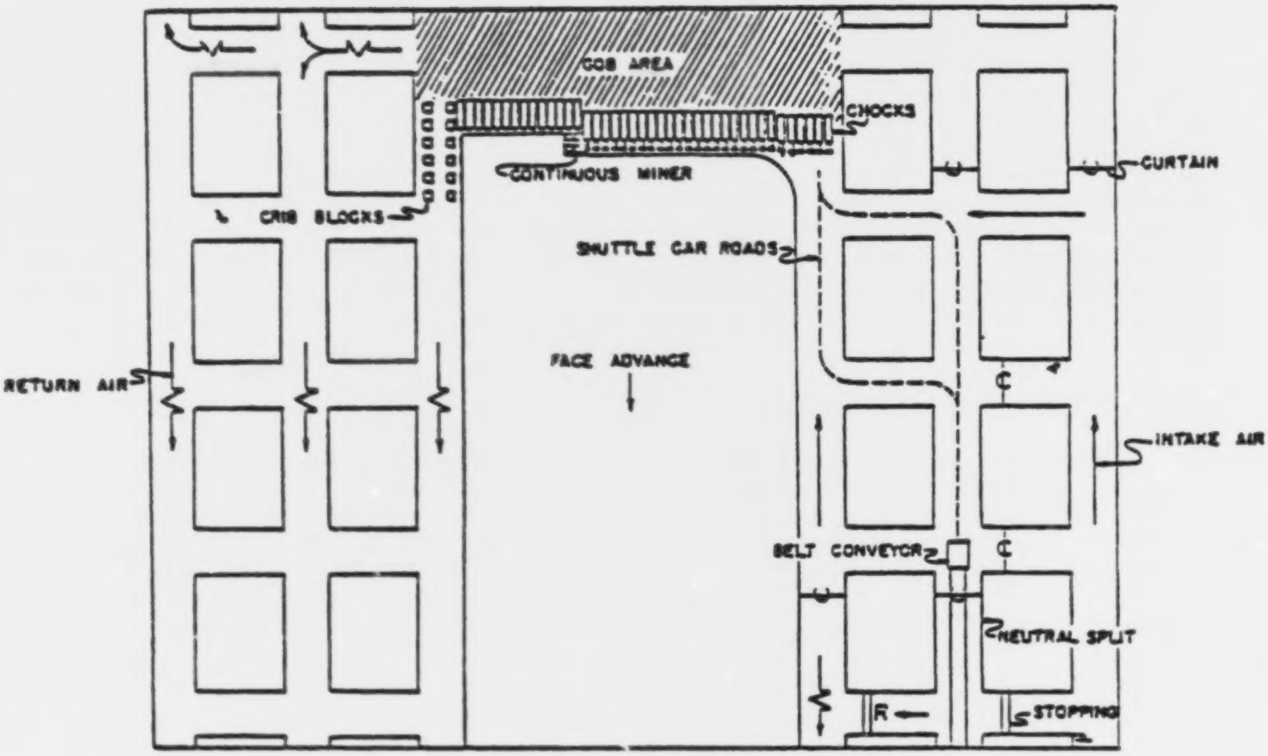

Figure IV-26
SHORTWALL MINING METHOD
(An experimental plan for shortwall mining in eastern Kentucky)

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Introduction

Coal preparation is the process of upgrading raw coal by physical means. In general, preparation techniques improve the heating value and physical characteristics of the coal by removing impurities such as pyrite and ash material (e.g., shales, clays, shaley coals, etc.). By removing potential pollutants such as sulfur-bearing minerals prior to combustions, coal cleaning can be an important control strategy for complying with air quality standards. The physical upgrading of metallurgical coal has long been a necessity because the steel industry has had the toughest quality requirements of all major coal-consuming industries. On the other hand, utility (steam) coal has been subjected to less extensive preparation. Although utility coal is required to be relatively uniform in size, the economic benefits accrued from deep cleaning in the past has not been sufficient to justify the additional preparation costs. However, with the establishment of new sulfur dioxide emission standards for power generating plants, there is a growing demand for more complete cleaning of utility coal. Electric utility companies can meet these standards by installing scrubbers or other technologies that reduce the sulfur content of stack gases, or by burning cleaner, lower sulfur coal.

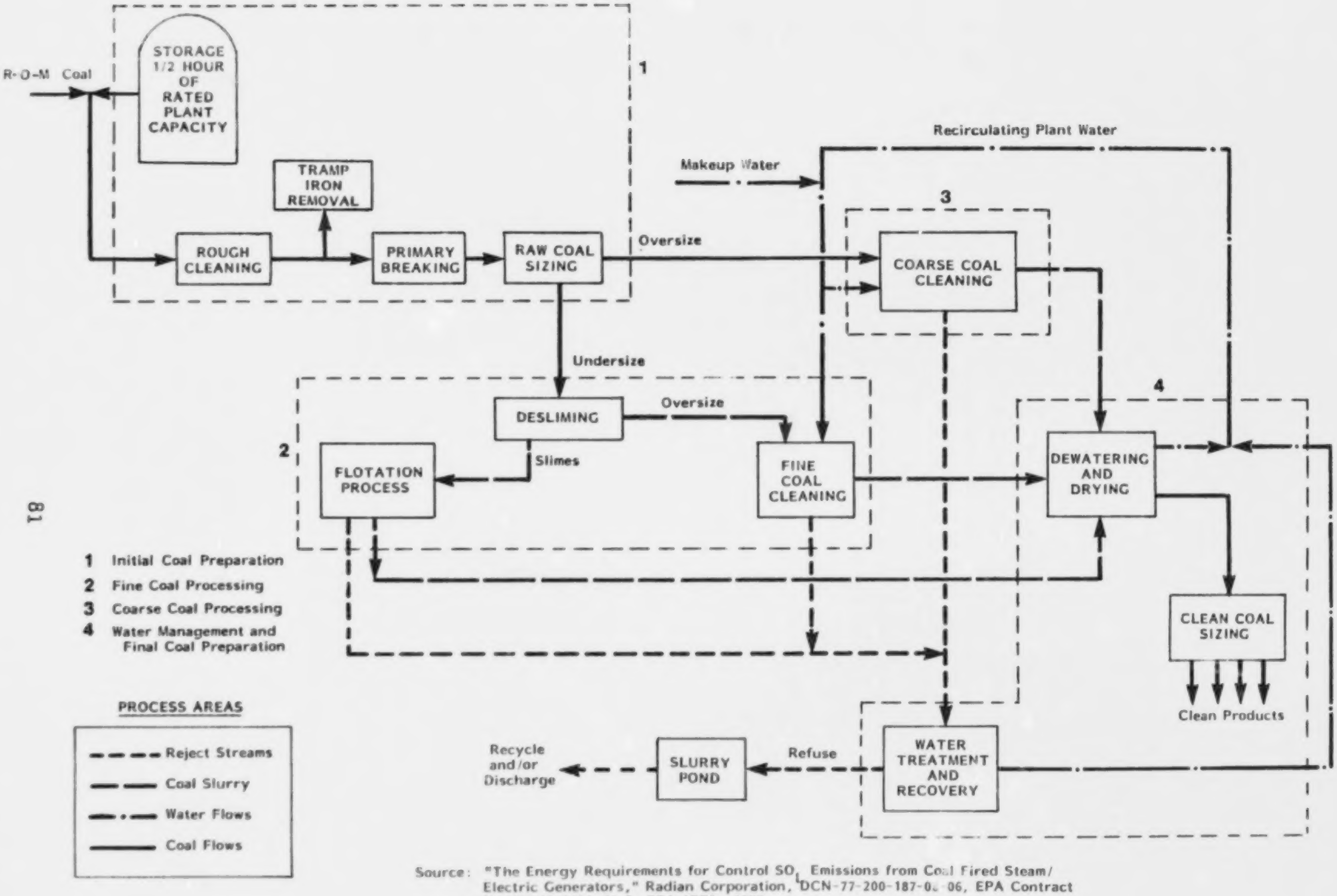
Coal Preparation Processes

The physical coal cleaning processes used today are oriented toward product standardization and reduction of ash, with increasing attention being placed on sulfur reduction. In a modern coal-cleaning plant, the coal is typically subjected to size reduction and screening, gravity separation of coal from its impurities, and dewatering and drying. The commercial practice of coal cleaning is primarily based on separation of the impurities due to differences in the specific gravity of coal constituents (i.e., gravity separation processes), and on the differences in surface properties of the coal and its mineral matter (i.e., froth flotation).

Although it is not possible to describe a universal coal preparation process, certain processing methods common to most preparation operations can be identified. Figure IV-27 illustrates a coal-cleaning facility that uses common process methods, without detailing specific unit operations.

Initial Coal Preparation

Prior to the actual cleaning process, run-of-mine coal must undergo initial preparation. This involves preliminary crushing of the coal to remove large rock fractions and to liberate entrained impurities such as clay, rock, and other inorganic materials, including pyrite. The first crushing step is followed by a screening operation and secondary crushing. A second screening step produces two product streams from this process area: one containing a fine fraction (usually less than 6.5 mm) and the other containing coarse particles (normally 76.0 x 6.5 mm). These two coal streams are then routed to



Source: "The Energy Requirements for Control SO_x Emissions from Coal Fired Steam/Electric Generators," Radian Corporation, DCN-77-200-187-02-06, EPA Contract No. 68-02-2608, U.S. EPA-IERL, 1977.

Figure IV-27. Simplified Flow Scheme--Physical Coal Cleaning Process

their respective process areas where the actual cleaning operation takes place (7).

Fine Coal Processing

Fine coal processing can involve either wet or dry cleaning methods. In plants utilizing a dry coal cleaning process, fine coal from the initial preparation step flows to a feed hopper and then to an air cleaning operation. This cleaning operation can employ one of several devices which rely on an upward current of air traveling through a fluidized bed of crushed coal. Separation is effected by particle size and density. Product streams from a dry cleaning process are sent directly to the final coal preparation step, while reject streams are usually processed further in wet cleaning operations (19).

In operations utilizing wet methods to effect fine coal cleaning, the process feed stream containing less than 6.5 mm coal is slurried with water as it enters the fine coal processing area of the plant. This slurry is then subjected to a desliming operation which removes a suspension containing approximately 50 percent of minus 200 mesh material. The cutoff size for this separation is usually in the range of 28 to 48 mesh. This desliming operation is necessary because the presence of slimes adversely affects the capacity and efficiency of fine cleaning units (19).

Subsequent to desliming, the oversize coal fraction (greater than 28 mesh) is pumped to the fine coal cleaning process. Here, fine coal particles undergo gravity separation in one of several wet cleaning devices. This removes a percentage of ash and pyritic sulfur to produce a clean coal product. The product stream from this operation is fed to the drying area of the plant; refuse material is further processed in the water treatment section.

The slimes removed from the fine coal stream are fed to a froth flotation process. Other material, such as reject from dry cleaning operations, may also be treated in the flotation process. This process consists of "rougher" and "cleaner" sections which are comprised of cells of flotation machines. Upon entering the flotation process area, the slime suspension is treated with a frothing agent. This agent selectively floats coal particles in the flotation machines while allowing pyrite and ash impurities to settle. Processing slime in the "rougher" cells produces a reject stream and a low-grade product. The low-grade product is further processed in the "cleaner" cells to produce a clean coal product. This final float product is then sent to the dewatering area for further handling, while reject material from both rougher and cleaner sections is processed in the water treatment and recovery area.

Coarse Coal Processing

Feed to the coarse coal processing area of the plant consists of oversize material (76 x 6.5 mm particles) from the initial preparation area. This feed stream is slurried with water prior to cleaning, since coarse coal cleaning operations employ wet processing equipment to remove impurities from the coal. The coarse coal slurry is fed to one of the many types of process equipment currently employed in coarse coal cleaning. Here, impurities are separated from the coal due to differences in product and reject density. It is common practice to remove a middling fraction from the separation operation and process it further by means of recycle or by feed to another cleaning process. These cleaning operations result in removal of two streams from the coarse coal processing area: a product and a reject stream. Subsequent to the coarse cleaning operation, the product stream is pumped to the dewatering and drying area of the plant, while the reject stream is processed in the water treatment recovery area.

Water Management/Refuse Disposal

Dewatering and drying equipment handle the product flows from both the fine and coarse coal preparation areas. Typically, cleaning plants employ mechanical dewatering operations to separate coal slurries into a low-moisture solid and clarified supernatant. The solid coal sludge produced in the dewatering step can be mechanically or thermally dried to further reduce the moisture. The supernatant from the dewatering process is returned to the plant water circulation system.

The water treatment and recovery section of a cleaning plant processes refuse slurries containing both coarse material and reject slimes. Here, the refuse slurry is dewatered, typically in thickeners and settling ponds. The supernatant from this operation is most often returned for reuse in the plant, while the refuse can be buried and revegetated to prevent burning, or piled prior to reclamation. The coal product from the dewatering and drying area of the plant often undergoes additional processing. This may involve crushing and screening operations to separate the product into various product sizes. The cleaned and sized product is then conveyed to storage silos or bins prior to shipping.

Plant Statistics

There was a total of 458 preparation plants processing anthracite, bituminous, and lignite coal in the United States in 1975 (18). (Current estimates (1979) indicate there are now approximately 670 preparation plants.) Based on 1976 data, 95 percent of the plants employed wet processing methods (see Figure IV-28). Only 21 plants used dry methods. Two-thirds of the wet processing plants utilized heavy media separation, froth flotation, or both. Table IV-10 shows bituminous and lignite tonnage processed in 1975 by type of cleaning method. Two hundred and forty-two million metric tons (267 million short tons) (41 percent) of 1975 production received mechanical cleaning using wet processing methods, whereas 288 million metric tons (317 million short tons) (49 percent) were subjected to crushing and/or screening only and 58 million metric tons (64 million short tons) (10 percent) received no processing prior to consumption. Table IV-11 breaks down mechanical cleaning of bituminous and lignite coal by type of equipment.

Table IV-10

BITUMINOUS COAL AND LIGNITE TONNAGE PROCESSED IN 1975

Type of Cleaning Method	kkg ÷ 10^6	Short Tons ÷ 10^6	Percent
Mechanical processing	242	267	41
Crushed or screened	288	317	49
No processing	58	64	10
Total 1975 production	588	648	100

Source (19)

Table IV-11

MECHANICAL CLEANING OF BITUMINOUS AND LIGNITE COAL IN 1975, BY TYPE OF EQUIPMENT

Type of Equipment	kkg ÷ 10^6	Short Tons ÷ 10^6	Percent
Washing Only Processes			
Jigs	113.0	124.3	46.6
Concentrating Tables	26.0	28.7	10.7
Classifiers	5.6	6.2	2.3
Launderers	2.4	2.7	1.0
Subtotal	147.0	161.9	60.6
Dense Media Processes			
Magnetite	65.7	72.4	27.1
Sand	12.2	13.5	5.1
Calcium Chloride	0.9	1.0	0.4
Subtotal	78.8	86.9	32.6
Flotation	10.4	11.5	4.3
Total Wet Methods	236.2	260.3	36.9
Pneumatic Methods	6.1	6.7	2.5
Grand Total	242.3	267.0	100.0

Source (17)

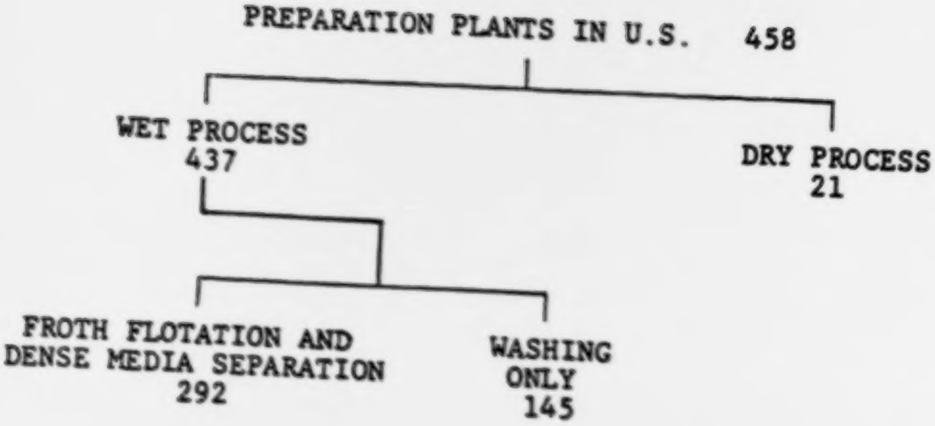

PREPARATION PLANTS IN U.S. 458
WET PROCESS 437
DRY PROCESS 21
FROTH FLOTATION AND DENSE MEDIA SEPARATION 292
WASHING ONLY 145

Figure IV-28

TYPES OF COAL PREPARATION PLANTS IN THE UNITED STATES

Source: (20)

Associated Areas

Associated areas include refuse piles, raw and clean coal stockpiles, applicable haulroads or access roads, and disturbed areas from preparation plant facilities; that is, areas associated with the preparation of and waste generated by a refined coal product. Refuse piles and coal stockpiles, plus other associated areas, can be prone to generation of acid waters, especially if high pyritic coals are involved. Proper management and treatment techniques are required to be used to minimize water pollution from these areas.

SECTION V

WASTEWATER CHARACTERIZATION AND INDUSTRY SUBCATEGORIZATION

INTRODUCTION

The development of effluent limitations guidelines is based upon the determination of the effluent characteristics of the industrial category and the identification of suitable treatment technologies for reduction of pollutants within the category. All industrial categories have inherent processing, site, or raw material differences which influence their effluent characteristics and methods of wastewater treatment. The purpose of this section is to recognize any of these major inherent differences that exist within the category, and more importantly, to determine their impact on treatability and effluent characteristics. The subcategorization scheme developed from this evaluation provides the basis for the selection of treatment technologies and the determination of effluent standards.

SUBCATEGORIZATION

The development of the BAT subcategorization scheme includes an examination of many factors which might affect effluent quality and treatability. The factors examined include mine type (surface or underground), coal type (anthracite, bituminous, lignite), size, location, and effluent source (preparation plant, active mine, or reclamation area). These factors were previously examined during the development of BPT effluent limitations, and a BPT subcategorization scheme was established. That subcategorization has been reexamined in light of additional data collected during the BAT program. Statistical and engineering analyses of these data indicate that several modifications are appropriate.

Revised BPT, BAT and NSPS Subcategorization Scheme

The following categorization provides the basis for the remainder of this study:

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1. Preparation Plants and Associated Areas (for NSPS, different standards apply to preparation plants and associated areas).

2. Acid Mine Drainage

3. Alkaline Mine Drainage

4. Post Mining Discharges
    a. Reclamation areas and
    b. Underground mine discharges.

SAMPLING AND ANALYSIS PROGRAM

To develop the regulations, data characterizing wastewaters generated during the extraction and preparation of coal were obtained and evaluated. The initial data collection effort was instituted during 1974 and 1975 for the development of BPT effluent limitations. These data included results from a sampling and analysis program and assimilation of a large amount of historical data supplied by the industry, the U.S. Bureau of Mines and other sources. This information characterized wastewaters from coal mining operations according to a number of key control parameters--acidity, alkalinity, total suspended solids, pH, iron, and others. However, little information on other pollutants such as toxic metals and organics were available from industry or government sources. To establish the levels of these pollutants, a second sampling and analysis program was instituted to specifically address these toxic compounds, including the 65 pollutants and pollutant classes for which regulation was mandated by the Clean Water Act Amendments of 1977. These pollutants are listed on Table VI-1. This sampling effort also served to extend the coal wastewater data base of conventional and nonconventional pollutants.

Data Base Developed During This Rulemaking

The Agency instituted a screening sampling program and a verification sampling program directed primarily at determining levels of the toxic pollutants in raw and BPT-treated effluents in the coal mining industry. Additional analytical data were obtained during engineering site visits to seventeen mine sites. Two EPA regional offices supplied supporting data from facilities within their geographical areas. Data generated from a self-monitoring program for areas during precipitation events and areas under reclamation are also part of the data base. A precision and accuracy study of settleable solids

Table V-1

DATA SOURCES DEVELOPED DURING BAT REVIEW FOR WASTEWATER CHARACTERIZATION

Number of Facilities by Proposed Subcategory

Data Source	Acid	Alkaline	Preparation Plants	Preparation Plant Associated Areas	Reclamation Areas
Screening	9	14	15	6	0
Verification	7	5	5	2	0
Engineering Site Visits	3	11	5	4	1
EPA Regional Studies	0	3	1	0	0
Self-Monitoring Survey	0	0	0	0	24
Prep. Plant Questionnaire	0	0	152	152	0
Prep. Plant Sampling	0	0	3	3	0
NPDES DMR	56	32	12	1	0
Site Specific Areas Under Reclamation	0	0	0	0	8
TOTALS	75	65	193	168	33

concentrations less than 1.0 ml/l was also performed. Finally, data from a preparation plant industry questionnaire and NPDES Discharge Monitoring Reports from four EPA regions have been compiled for addition to the active data base. These data sources are presented, by proposed subcategory, in Table V-1 and discussed in more detail below. Table V-2 summarizes statistics for the data base upon which coal industry wastewaters are characterized. A number of treatability studies were also conducted to evaluate the capacity of candidate technologies to treat coal mine drainage. These studies are summarized in Table V-3. Results from the treatability studies are discussed in detail in Section VII, Treatment and Control Technologies. Special reports for anthracite mining, sedimentation pond sludge samples and coal preparation plants were also prepared. (See Ref 21.22, and 23 respectively).

Data Sources

Screening and Verification Sampling

The screening and verification sampling program began in 1977. Several criteria were considered in the selection of sampling sites. It was determined that facilities to be sampled should: 1. Be representative of the industry to account for all major factors (i.e., location, topography, seam characteristics, etc.) which could influence effluent quality and treatability; and 2. Include treatment processes considered exemplary within the industry to establish a baseline for best available technologies. Applying these criteria, a candidate list of sites was prepared and submitted to the Water Quality Committee of the National Coal Association for comment. A final list of sites to be visited for the screening phase was then compiled. The mine companies were contacted and sampling arrangements made. Screening sampling visits were conducted during 1977 to sites within the various subcategories as listed in Table V-1. All sampling and analysis during this phase were done according to EPA sampling protocols (8). After review of screen sampling analytical results, several additional sites were selected for verification sampling. Three coal mines and preparation plants were revisited to verify data collected during screening. Three additional bituminous and lignite mines, as well as four anthracite facilities, were also sampled to enhance the representativeness of the data base. Sampling and analytical protocols for this phase were all in accordance with EPA procedures (8). More detail on these protocols can be found in Appendix C, of the Proposed Coal Mining Development Document. (EPA 440/1-81/057/b).

Engineering Site Visits

The engineering site visits were carried out primarily to collect cost data for verifying and supplementing costs previously developed for the coal mining industry. Fourteen separate mines, some with an associated preparation plant, were contacted and visited in the fall of 1979. A sample data checklist used on the visits may be found in Appendix D of the Proposed Coal Mining Development Document. Samples

Table V-2

DATA BASE SOURCES

	Type of Facility	
	Anthracite, Bituminous Coal and Lignite Mines	Preparation Plants and Associated Areas
BPT Study	89	34
BCRI Surveys	162	118
*BAT Screening and Verification	29	19
*Self-Monitoring Survey	17	0
*EPA Region IV, VIII	3	1
*Engineering Site Visits	14	8
*Preparation Plant Site Visits	0	3
*Preparation Plant Industry Survey	0	152
Total No. in Data Base	314	335
Total No. of Independent Facilities in Computerized Data Base	58	167
Percent of 1978 Total Production Represented in Total Data Base	39	43

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*Data from this source has been computerized.

Table V-3

TREATABILITY STUDIES CONDUCTED ON COAL MINE DRAINAGE

Technology Examined	Site(s) of Study or Mine(s)	Type of Drainage Treated	Dates of Effort	Reference
Lime/Limestone	Crown, WV	Acid Mine Drainage (Ferrous Iron)	1974-1976	(1)
Lime/Limestone	Norton, WV	Acid Mine Drainage (Ferric Iron)	1974	(2)
Reverse Osmosis	Norton, WV Morgantown, WV Ebensburg, PA Mocanaqua, PA	Acid Mine Drainage	1972	(3)
Flocculant Addition	Norton, WV Hollywood, PA Crown, WV Stonefort, IL	Acid Mine Drainage	1979	(4)
Granular Media Filtration	Ebensburg, PA Greensboro, PA	Acid Mine Drainage Acid Mine Drainage	1980	(5)
Neutralization Aeration Ozonation Sand Filtration Carbon Adsorption	Crown, WV	Acid, Alkaline Mine Drainage for Organics and Toxic Metals	1978-1979	(6)
Reverse Osmosis Ion Exchange Lime Neutralization	Crown, WV	Acid Mine Drainage	1978	(7)

of raw and treated effluents were collected and shipped for analysis of "classical" parameters (TSS, Fe, Mn, pH, turbidity, alkalinity/acidity, settleable solids, and total dissolved solids) and the thirteen toxic metals. The analytical protocol used was established by EPA. The metals were analyzed by inductively-coupled argon- plasma emission spectrometry and atomic adsorption (9).

EPA Regional Support Studies

EPA Region 8 (Denver, Colorado) instituted a sampling effort to assess the water treatment configurations and effluent qualities characteristic of the western coal producing region. Several mines were visited during the spring of 1979; however, due to an unusually mild winter and an abnormally dry spring, only two of those contacted were found to have a discharge that could be sampled. Grab samples were collected and analyzed for the currently regulated parameters, priority metals, and a number of nonconventional pollutants. EPA Region 4 (Atlanta, Georgia) conducted a similar effort at one mine in its region. These data were forwarded to the Effluent Guidelines Division and incorporated into the data base. This information was incorporated into a report comparing effluents from eastern and western mines.(10) The data was also used to further characterize mine drainage and wastewater treatability, particularly for priority metals removal.

Preparation Plant Industry Survey

This study was conducted with the cooperation of the National Coal Association (NCA) to assess water usage and treatment in coal preparation plants. NCA producer companies were mailed a questionnaire requesting the following information: facility profile, water balance around the preparation facility, makeup water sources, discharge points and quantities, water treatment practices employed, water management procedures and acreage of preparation plant associated areas, and effluent quality data. A sample questionnaire is in Appendix D of the Proposed Coal Mining Development Document (EPA 440/1-8/057-b) for the proposed rulemaking. One hundred and fifty-two plants (approximately 50 percent of the NCA producer company preparation plants) responded to the survey, representing roughly 30 percent of all the plants in the industry. This information was incorporated into the computer data base developed in support of the overall program, and may be found in Appendix E of the Proposed Coal Mining Development Document (EPA 440/1-81/057-b). The uses of the industry responses include the following:

1. Determination of the number of plants operating a total recycle system;

2. Determination of requirements for modifying current treatment configurations to a total recycle system; and

3. Determination of the runoff treatment strategy for areas ancillary to the preparation plant.

Questionnaire results are discussed in Section VII, Treatment and Control Technology.

Self-Monitoring Survey

A one year survey conducted under authority of Section 308 of the Clean Water Act was performed in order to characterize surface discharges from sedimentation pond effluents during and after storms and also for reclamation areas. (See Appendix A of this document). Seventeen mining facilities involving 24 ponds reported data. Sampling of one pond ended shortly after the study because the facility discontinued discharging into it. Four other ponds did not report a discharge during the study. Therefore, data was collected from a total of 19 ponds.

Samples were taken of the influent to and effluent from the ponds. One sample per week was collected to establish base flow conditions, with additional samples taken during any significant rainfall event and the day after the rainfall event. The results of these sample analyses, coupled with design specifications submitted by the participating companies for each pond, permitted identification of the treatment effectiveness of the ponds during dry weather and storm conditions, as well as concentrations of pollutants which characterize runoff from mining areas. The parameters analyzed include total suspended solids, settleable solids, total iron, dissolved iron, and pH. Certain samples were also analyzed for the priority metals. (After the first six months' of the toxic metals analyses, results were so low that sampling for these parameters was discontinued).

Settleable Solids Precision and Accuracy Study

A second major sampling and analysis effort was performed to develop a precision and accuracy determination for measurement below 1.0 ml/l of settleable solids for active mining and reclamation area discharges from eastern and western coal mines. (See Appendix B of this document). Under this program, eight treatment ponds were sampled and analyzed for settleable solids using the Standard Methods protocol (14th Ed., American and Public Health Association, Washington, D.C., 1975). Based on the results of this study, EPA has concluded that it is possible to measure settleable solids below 1.0 ml/l and that an effluent limitation below 1.0 ml/l is indeed reasonable. In fact, EPA concluded that the maximum method detection limit for settleable solids in the coal mining industry is 0.4 ml/l.

Preparation Plant Sampling Program

This sampling and analysis effort was instituted to characterize preparation plant effluents and to compare wastewater generated within total recycle systems with wastewater discharged from partial recycle and once-through systems. Grab samples were collected at three preparation plants and associated areas and analyzed according to Agency protocol (8). Cost and wastewater engineering data were collected simultaneously to augment existing data and to permit an evaluation of the feasibility of no discharge of pollutants from preparation plant water circuits.

Regional Discharge Monitoring Reports (DMR) Filed Under the NPDES Program

A program was conducted to collect DMRs from EPA regional offices located in the major coal producing areas in the United States. These data identify the levels of variation in flow and pollutant characteristics associated with mine drainage. Of particular interest is the daily maximum value of each regulated pollutant (TSS, Fe, Mn, and pH) during the 30-day monitoring period. Eighty-eight sets of data were obtained from EPA Regions 3, 4, 5, and 8.

WASTEWATER SOURCES AND CHARACTERISTICS

Water enters surface or deep mines by groundwater infiltration, precipitation, and surface runoff. Surface runoff can become contaminated with suspended solids from sediment. If pyritic material is exposed on the mine bottom, highwall, or spoil piles, oxidation and acid formation can occur and leach toxic metals. Groundwater entering a surface or deep mine is also subject to acid formation.

The wastewater situation at coal mines is notably different from that found in most other industries. No process water is used in coal extraction, except for minor use in dust suppression, equipment cooling, and firefighting needs. Water is an operational hindrance to a coal mine, and requires careful management to minimize water entering the active mining area. Water can cause occupational health hazards, such as spoil bank or highwall instability or an electrical short circuit in the case of operations using electric trunk lines to power mining equipment. As indicated in the industry profile section, the quantities of water generated at a mine site do not correlate with the coal production rate. This again differs from most other industries, where flow, and thus pollutant loadings, can be linked with the rate of production.

A final major difference with water management in the coal industry is the possibility of continuing discharges of polluted wastewater after the facility has ceased production, especially from underground operations. Control practices, which are discussed in Section VII, can be implemented to minimize or treat these discharges during and after the active mining phase.

This subsection will summarize raw wastewater data first for all subcategories and then for each individual proposed subcategory. The data sources in the summary tables include the following:

1. Screening sampling data,
2. Verification sampling data,
3. Self-monitoring survey data,
4. EPA regional data,
5. Engineering site visits,
6. Preparation plant site visits.

A number of explanatory points should be made to correctly interpret the tables presented in this section and the next section. First, all concentrations are presented in micrograms per liter, listed as UG/L on the tables.

Second, the tables represent an effort to illustrate the quantity and distribution of the data. Thus, the total number of samples analyzed for each pollutant parameter is listed in the first numerical column. The second column presents the total number of times the pollutant was detected during analysis. Because the Agency considers 10 ug/l as a realistic lower limit for detection of organic compounds (5 ug/l for pesticides), the third column depicts the total number of samples where a detected value of greater than 10 ug/l was found. These are termed "quantifiable levels." The final six columns are an attempt to illustrate the data distribution of only the detected values. The statistics listed include the minimum, the 10 percent value (i.e., 90 percent of the detected values are above this concentration), the median of detected values, the mean of detected values, the 90 percent value (90 percent of the detected values are below this value), and the maximum reported concentration. Nearly all the organic priority pollutants and a number of the toxic metal pollutants are most frequently found as "not detected," i.e., below the detection limit. To record these values on the final five columns would render these columns essentially meaningless. For instance, cyanide was detected in only three samples out of 50 for raw wastewater (see Table V-4). If the not detected values were recorded in the final five columns, the minimum, the 10 percent value, the median, and the 90 percent value would all be listed as not detected. This may be appropriate for some types of evaluation, but, for the purpose of developing treatment technologies and supporting a subcategorization scheme, illustrating the data distribution for detected values is more informative.

Third, in situations where fewer than 10 detected values occur, no meaningful number could be selected to represent the 10 percent and 90 percent values. This is denoted by an asterisk. Dots in the minimum, mean, median, and maximum columns indicate no values were detected for that parameter.

Fourth, concentrations were sometimes reported by the analytical laboratory as "detected less than X" where X equals some detection limit. This apparently contradictory information can be explained by

Table V-4

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	49	3	0	3	*	3	3	*	3
ACROLEIN	47	0	0	.	*	.	.	*	.
ACRYLONITRILE	47	0	0	.	*	.	.	*	.
BENZENE	47	13	8	2	2	18	24	47	73
BENZIDENE	49	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	47	0	0	.	*	.	.	*	.
CHLOROBENZENE	46	1	1	12	*	12	12	*	12
1,2,3-TRICHLOROBENZENE	49	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	49	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	47	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	47	4	1	3	*	3	8	*	23
HEXACHLOROETHANE	49	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	47	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	47	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	47	0	0	.	*	.	.	*	.
CHLOROETHANE	47	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	47	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	49	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	47	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	49	1	0	3	*	3	3	*	3
2,4,6-TRICHLOROPHENOL	46	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	46	0	0	.	*	.	.	*	.
CHLOROFORM	47	25	22	3	8	32	95	306	476
2-CHLOROPHENOL	46	1	1	86	*	86	86	*	86
1,2-DICHLOROBENZENE	49	2	1	3	*	3	11	*	18
1,3-DICHLOROBENZENE	49	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	49	1	0	3	*	3	3	*	3
3,3-DICHLOROBENZIDINE	46	0	0	.	*	.	.	*	.

Table V-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	47	3	0	3	*	3	3	*	3
1,2-TRANS-DICHLOROETHYLENE	47	1	0	10	*	10	10	*	10
2,4-DICHLOROPHENOL	46	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	47	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	47	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	46	3	3	18	*	20	21	*	24
2,4-DINITROTOLUENE	49	1	1	18	*	18	18	*	18
2,6-DINITROTOLUENE	49	1	1	30	*	30	30	*	30
1,2-DIPHENYLHYDRAZINE	49	1	0	3	*	3	3	*	3
ETHYLBENZENE	48	4	1	2	*	3	5	*	11
FLUORANTHENE	49	5	2	3	*	3	6	*	11
4-CHLOROPHENYL PHENYL ETHER	49	1	0	3	*	3	3	*	3
4-BROMOPHENYL PHENYL ETHER	49	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	49	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	49	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	47	43	34	3	3	501	1188	2201	11190
METHYL CHLORIDE	47	0	0	.	*	.	.	*	.
METHYL BROMIDE	47	0	0	.	*	.	.	*	.
BROMOFORM	47	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	47	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	47	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	47	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	47	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	49	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	49	0	0	.	*	.	.	*	.
ISOPHORONE	49	1	1	307	*	307	307	*	307
NAPHTHALENE	48	10	8	2	2	10	75	220	410
NITROBENZENE	49	1	1	21	*	21	21	*	21

Table V-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	46	1	1	17	*	17	17	*	17
4-NITROPHENOL	46	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	46	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	46	1	1	194	*	194	194	*	194
N-NITROSODIMETHYLAMINE	49	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	49	1	1	45	*	45	45	*	45
N-NITROSODI-N-PROPYLAMINE	49	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	46	0	0	.	*	.	.	*	.
PHENOL	46	6	1	3	*	3	5	*	16
BIS(2-ETHYLHEXYL) PHTHALATE	49	21	12	3	3	9	16	44	62
BUTYL BENZYL PHTHALATE	49	4	0	3	*	3	3	*	3
DI-N-BUTYL PHTHALATE	49	19	3	2	3	3	4	6	11
DI-N-OCTYL PHTHALATE	49	1	0	3	*	3	3	*	3
DIETHYL PHTHALATE	49	11	1	1	1	3	5	3	23
DIMETHYL PHTHALATE	49	1	0	3	*	3	3	*	3
BENZO(A)ANTHRACENE	46	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	49	7	2	1	*	3	24	*	141
BENZO(B)FLUORANTHENE	49	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	49	3	2	1	*	4	6	*	11
CHRYSENE	46	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	49	1	1	9	*	9	9	*	9
ANTHRACENE	46	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	49	7	1	1	*	3	5	*	10
FLUORENE	49	5	2	1	*	3	14	*	44
PHENANTHRENE	46	1	1	12	*	12	12	*	12
DIBENZO(A,H)ANTHRACENE	49	5	0	3	*	3	5	*	10
INDENO(1,2,3-C,D)PYRENE	49	4	0	3	*	3	6	*	10
PYRENE	49	6	2	1	*	3	9	*	25

Table V-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	47	0	0	.	*	.	.	*	.
TOLUENE	47	16	10	2	2	11	16	40	46
TRICHLOROETHYLENE	47	1	0	3	*	3	3	*	3
VINYL CHLORIDE	47	0	0	.	*	.	.	*	.
ALDRIN	45	1	0	6.40	*	6.40	6.40	*	6.40
DIELDRIN	45	3	0	2.24	*	2.24	2.28	*	2.30
CHLORDANE	46	0	0	.	*	.	.	*	.
4,4-DDT	45	0	0	.	*	.	.	*	.
4,4-DDE	45	1	0	2.24	*	2.24	2.24	*	2.24
4,4-DDD	45	1	0	2.24	*	2.24	2.24	*	2.24
ENDOSULFAN-ALPHA	45	3	0	0.10	*	1.17	1.52	*	2.24
ENDOSULFAN-BETA	45	2	0	2.24	*	2.24	2.24	*	2.24
ENDOSULFAN SULFATE	46	0	0	.	*	.	.	*	.
ENDRIN	46	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	45	2	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR	45	2	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR EPOXIDE	45	3	0	0.20	*	1.22	1.56	*	2.24
BHC-ALPHA	45	5	0	1.10	*	2.24	2.08	*	2.60
BHC-BETA	45	6	0	0.33	*	1.40	1.47	*	2.24
BHC (LINDANE)-GAMMA	45	5	0	0.43	*	2.24	1.87	*	2.24
BHC-DELTA	45	5	0	0.10	*	1.23	1.41	*	2.24
PCB-1242 (AROCHLOR 1242)	46	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	46	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	46	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	46	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	46	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	46	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	46	0	0	.	*	.	.	*	.

Table V-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	48	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	49	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	45	10	5	2	2	3	24	48	104
BENZO(A)ANTHRACENE/CHRYSENE	19	6	2	1	*	3	15	*	49
BENZO(3,4/K)FLUORANTHENE	18	3	1	3	*	3	4	*	7
ANTIMONY (TOTAL)	103	45	22	1	2	7	40	117	235
ARSENIC (TOTAL)	104	49	28	2	2	38	345	863	6500
BERYLLIUM (TOTAL)	104	32	17	0	1	10	39	92	450
CADMIUM (TOTAL)	104	24	22	6	10	17	42	92	290
CHROMIUM (TOTAL)	104	64	58	6	10	50	286	508	7500
COPPER (TOTAL)	104	75	58	4	6	20	429	1145	6500
CYANIDE (TOTAL)	57	3	0	2	*	4	6	*	8
LEAD (TOTAL)	104	41	32	2	3	67	491	1000	5500
MERCURY (TOTAL)	104	44	6	0.20	0.33	1.10	4.99	14.20	43.00
NICKEL (TOTAL)	104	51	51	23	40	153	729	1210	10000
SELENIUM (TOTAL)	104	39	23	1	3	22	66	213	450
SILVER (TOTAL)	104	32	20	4	5	13	18	31	64
THALLIUM (TOTAL)	104	27	12	1	1	9	26	66	184
ZINC (TOTAL)	104	91	88	7	15	99	1408	2897	30000

Table V-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
ALL SUBCATEGORIES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	98	97	500	2570	57500	1016E4	1460E4	2400E5
PH (UNITS)	100	100	2.4	3.6	7.5	6.9	8.2	9.4
IRON (TOTAL)	105	104	11	209	2230	257576	687997	9000E3
MANGANESE (TOTAL)	103	94	3	25	1075	5190	12600	80000
ASBESTOS(TOTAL-FIBERS/LITER)	10	9	3500E3	*	1090E6	9372E6	*	4100E7
COD	57	52	40	8180	34000	1009E4	3094E4	2220E5
DISSOLVED SOLIDS	38	38	71000	145000	730000	1130E3	2580E3	3200E3
TOTAL VOLATILE SOLIDS	42	41	10000	43400	222167	6968E3	2494E4	8051E4
VOLATILE SUSPENDED SOLIDS	28	22	1000	1080	4800	1418E3	751992	2800E4
SETTLEABLE SOLIDS	65	53	0.0	0.0	0.7	126.6	378.7	1800.0
TOTAL ORGANIC CARBON	56	49	260	1256	14150	1322E3	3022E3	2847E4
FREE ACIDITY (CACO3)	6	6	19000	*	41000	181500	*	740000
MO ALKALINITY (CACO3)	33	33	10	7967	190000	392425	587000	5400E3
PHENOLICS(4AAP)	56	11	2	2	20	33	50	155
SULFATE	8	8	130000	*	503333	659583	*	1530E3
TOTAL ACIDITY (CACO3)	1	1	10500	*	10500	10500	*	10500
TOTAL SOLIDS	35	35	180000	314850	1326E3	9689E3	1180E4	1900E5

evaluating common laboratory procedures. The analytical machines used for these samples frequently have a significant degree of background noise, often due to 60 Hz electrical frequencies and internal electrical phenomena which on the readout can partially or totally mask the signature of a compound. This level of noise is one factor which is accounted for in the determination of the detection limit. In most laboratory analyses, the signatures of the desired compounds that are partially masked can be identified by a skilled lab technician. The concentration is thus reported as being detected, but at less than the detection limit. For computational purposes, a method for quantifying these detected values is needed. Thus, in the accompanying tables, for values reported as "detected less than X," where X equals some detection limit, the value was calculated and recorded on the table as 1/2 of X when X was less than 4 ug/l and as the square root of X when X was greater than 4 ug/l.

Fifth, some values were too large to put in a column in decimal notation; these are recorded in exponential notation with an "E" prior to an integer number of zeros. For example, on the sixth page of Table V-4 for the total suspended solids mean value, a level of 1016E4 is recorded. This should be interpreted as 10,160,000 ug/l.

Sixth, to accurately analyze the data, factors which could bias the data should be minimized or eliminated. Two particular instances should be noted. First, each piece of data is coded according to a number of identifying parameters, one of which is its sample type (e.g., raw wasteload, partially treated stream, final discharge). To include multiple analyses of the same raw effluent source would be redundant and introduce bias. Thus, for four facilities (00013, 00014, 00009, 00010), multiple raw effluent points were averaged for each facility to yield one raw effluent data point per facility. A second similar situation occurred when multiple samples were taken of the same sample point over a period of days. For instance, three days of verification sampling of the same point were averaged to yield one distinct data point before statistical calculations were performed. This also avoids unnecessary bias.

Finally, three pairs of priority organic compounds cannot be distinguished using GC/MS equipment. They are anthracene/phenanthrene, benzo(a)anthracene/chrysene, and benzo(3,4)fluoranthene/benzo(k)fluoranthene (abbreviated on the table as benzo(3,4/k)fluoranthene). The dual compounds are reported prior to the priority metals data as one concentration value for each pair. The data for raw wastewater from coal mines for all proposed subcategories are summarized in Table V-4. This table permits an overview of the characterization of mine drainage. The following subsections present sources and data on raw effluent for each proposed subcategory.

Acid Mine Drainage

Formation of Acid Mine Drainage

Iron sulfide, or pyrite, is a common substance formed from mineral sulfur. It is this sulfur-containing compound that is a precursor to acid mine drainage. As water drains across or percolates through pyritic material, in the presence of oxygen, the formation of acid drainage occurs in two steps (13, 12). The products of the first step are ferrous iron and sulfuric acid as shown in equation 1.

$$2FeS_2 + 7O_2 + 2H_2O \longrightarrow 2FeSO_4 + 2H_2SO_4 \qquad (1)$$

The ferrous iron (Fe+2) then undergoes oxidation to the ferric state (Fe^{+3}) as shown in equation 2.

$$4FeSO_4 + 2H_2SO_4 + O_2 \longrightarrow 2Fe_2(SO_4)_3 + 2H_2O \qquad (2)$$

The reaction may proceed to form ferric hydroxide or basic ferric sulfate as shown in equations 3 and 4 respectively.

$$Fe_2(SO_4)_3 + 6H_2O \longrightarrow 2Fe(OH)_3 + 3H3{=}2SO_4 \qquad (3)$$

$$Fe_2(SO_4)_3 + 2H_2O \longrightarrow 2Fe(OH(SO_4)) + H_2SO_4 \qquad (4)$$

The ferric iron can also directly oxidize pyrite to produce more ferrous iron and sulfuric acid as shown in equation 5.

$$FeS_2 + 14\,Fe^{+3} + 8H_2O \longrightarrow 15\,Fe^{+2} + 2SO_4^{-2} + 16H^+ \qquad (5)$$

Thus, the oxidation of one mole of iron pyrite yields two moles of sulfuric acid. As the pH of the pyritic systems decreases below five, certain acidophilic, chemoautotrophic bacteria become active. These bacteria, *Thiobacillus ferroxidans*, *Ferrobacillus ferroxidans*, *Metallogenium*, and species are active at pH 2.0 to 4.5 and use CO_2 as their source (20). These bacteria are responsible for the oxidation of ferrous iron to the ferric state, the rate limiting step in the oxidation of pyrite. Their presence is generally an indication of rapid pyrite oxidation and is accompanied by waters low in pH and high in iron, manganese, and total dissolved solids. The acid formed from these reactions is an effective extraction agent, causing trace elements to be leached and dissolved into solution. The solubilities of these substances, mostly heavy metals, are very sensitive to changes in pH. This is illustrated in Figure V-1. The data on this figure are derived from an experimental study of acid mine drainage (7). Acid drainage can be readily formed by rainfall upon either a coal storage or a refuse pile. These wastewaters can be high in certain metals concentration, especially after a substantial rainfall event (12). Also, acid waters can be formed in underground mines and aquifers if sufficient air is present to permit oxidation of pyritic materials in either the coal seam or adjacent strata. The leaching process is promoted by a long contact time for water and the sulfur-containing material.

Characteristics of Acid Mine Drainage

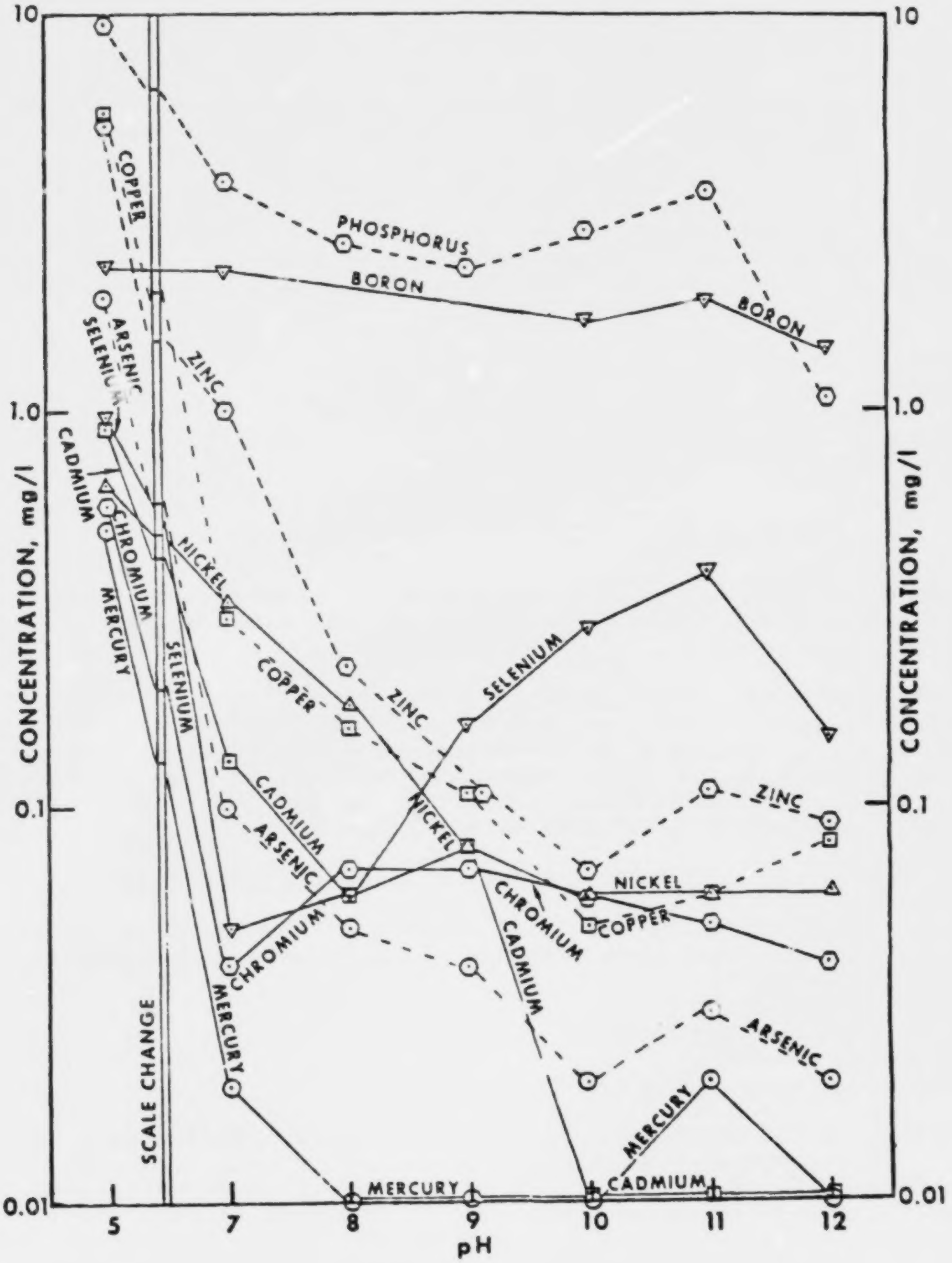

Figure V-1
CONCENTRATIONS OF CERTAIN ELEMENTS AS A FUNCTION OF pH

Source: (7)

The principal pollutants in surface water from mines exhibiting acid mine drainage include suspended and dissolved solids, pH, and certain metal species. Causes for the formation of low pH and high metals concentrations have just been discussed. In general, the problem of acid mine drainage is confined to western Maryland, northern West Virginia, Pennsylvania, Ohio, western Kentucky, and along the Illinois - Indiana border. Acid drainage is not serious in the West because the coals and overburden contain little pyrite and because the amount of infiltration into spoils is low due to low rainfall (16, 15). Suspended solids result from erosion of scarified areas, where vegetation has been removed. The level of sediment concentration in runoff is a function of the following:

1. Slope of the area
2. Residual vegetation
3. Soil type
4. Surface texture
5. Drainage area
6. Precipitation intensity and duration
7. Existing soil moisture
8. Particle or aggregate size.

The number and interaction of these variables render wide variations in raw wastewater from day to day in any one mine, and from mine to mine in a given region.

Dissolved solids can result from infiltration of precipitation that leaches through spoil and coal piles. Acid leaching of soil and coal, and ion exchange reactions of runoff and soil also cause the formation of this pollutant. Calcium, magnesium, and sodium are the principal dissolved materials in surface runoff. The factors affecting the quantity of wastewater generated by a surface mine include:

1. Frequency, intensity, and duration of precipitation and snowmelt events
2. The number, porosity and water content of any aquifers above or including the coal seam that are mined through or breached
3. Drainage area
4. Soil porosity
5. Pump capacity and rate
6. Evaporation rate
7. Watershed slope and flow length.

Groundwater is the primary source of drainage from underground mining sites. Underground operations in or below aquifers can cause localized decline of the water table, changes in flow direction and possible changes in flow rate (16). Lowering of water levels may cause wells or springs in the vicinity to dry up. Fracturing as a result of subsidence may similarly alter groundwater flow. In addition, the presence of subsidence fractures and depressions at the surface may increase groundwater recharge in the vicinity of the mine (17). Underground mining may also cause degradation of groundwater quality. Flow of groundwater through a mine with acid forming potential may result in leaching of soluble materials including trace metals and other ions that will cause an increase in dissolved solids content and may contaminate groundwater supplies.

During the screening phase, facilities 00005, 00012, 00017, 00018, and 00021 through 00024 were sampled. For facility 00012, drainage from inactive mine areas was the source of acid drainage. Verification sampling was conducted at mines 00198, 00021, 00023, 00188 through 00190, and 00197. Descriptions of the above facilities and treatment process schematics, including sampling points, can be found in Appendix F of the Proposed Coal Mining Development Document (EPA 440/1-81/057-b). Engineering site visits were conducted at mines 00035, 00038, and 00195. Data for toxic pollutants, and conventional and nonconventional pollutants in untreated acid mine drainage appear in Table V-5. As can be seen from the table, organics concentrations are very low from these mining operations. In contrast, conventional and toxic metals concentrations are often quite substantial. All raw data are contained in Appendix B of the Proposed Coal Mining Development Document (EPA 440/1-81/057-b).

Alkaline Mine Drainage

The discussion on sediment concentrations and wastewater quantity in the acid mine drainage subsection is also applicable to alkaline mine drainage and will not be repeated here. Facilities 00001, 00002, 00003, 00004, 00006, 00007, 00011, 00013, 00014, 00015, 00016, 00019, 00020, and 00025 were sampled during the screening phase. During verification sampling, mines 00011, 00018, and 00025 were revisited and mines 00009 and 00010 were sampled for the first time. Mine 00018 is also listed under acid mines during the screening phase because it possesses both acid raw effluents and alkaline raw effluents. These samples were appropriately divided and recorded on the proper table. Descriptions of the above facilities and treatment schematics, including sampling points, can be found in Appendix F of the Proposed Coal Mining Development Document (EPA 440/1-81/057-b). Mines 00009, 00032, 00033, 00034, 00036, 00037, 00103, 00107, 00193, 00194, and 00196 were sampled during the engineering site visits. EPA Region 8 sampled mines 00029 and 00030. EPA Region 4 sampled facility 00031. Data for toxic pollutants and conventional and nonconventional pollutants from all these sources are summarized in Table V-6. As shown on the table, organics concentrations and metals concentrations are both very low. Further, conventional pollutants with the exception of TSS are very low. The raw data are contained in Appendix B of the Proposed Coal Mining Development Document.

Preparation Plants

Wastewater is generated in a coal preparation plant from the coal cleaning process. Flow rates vary widely depending upon certain factors such as the degree of cleaning, the equipment or processes used, and the characteristics of the run-of-mine coal. Each of these factors was discussed in detail in Section IV. Physical coal cleaning removes impurities from coal via a mechanical separation process. In

Table V-5

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	17	0	0	.	*	.	.	*	.
ACROLEIN	16	0	0	.	*	.	.	*	.
ACRYLONITRILE	16	0	0	.	*	.	.	*	.
BENZENE	16	8	4	2	*	18	20	*	40
BENZIDENE	17	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	16	0	0	.	*	.	.	*	.
CHLOROBENZENE	16	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	17	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	17	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	16	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	16	0	0	.	*	.	.	*	.
HEXACHLOROETHANE	17	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	16	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	16	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	16	0	0	.	*	.	.	*	.
CHLOROETHANE	16	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	16	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	17	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	16	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	17	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	14	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	14	0	0	.	*	.	.	*	.
CHLOROFORM	16	9	9	16	*	34	101	*	442
2-CHLOROPHENOL	14	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	17	0	0	.	*	.	.	*	.
1,3-DICHLOROBENZENE	17	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	17	0	0	.	*	.	.	*	.
3,3-DICHLOROBENZIDINE	16	0	0	.	*	.	.	*	.

Table V-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	16	0	0	.	*	.	.	*	.
1,2-TRANS-DICHLOROETHYLENE	16	1	0	10	*	10	10	*	10
2,4-DICHLOROPHENOL	14	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	16	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	16	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	14	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	17	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	17	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	17	0	0	.	*	.	.	*	.
ETHYLBENZENE	17	2	0	2	*	2	3	*	4
FLUORANTHENE	17	0	0	.	*	.	.	*	.
4-CHLOROPHENYL PHENYL ETHER	17	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	17	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	17	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	17	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	16	16	15	7	10	487	1596	3804	11190
METHYL CHLORIDE	16	0	0	.	*	.	.	*	.
METHYL BROMIDE	16	0	0	.	*	.	.	*	.
BROMOFORM	16	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	16	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	16	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	16	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	16	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	17	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	17	0	0	.	*	.	.	*	.
ISOPHORONE	17	0	0	.	*	.	.	*	.
NAPHTHALENE	17	3	1	2	*	4	6	*	10
NITROBENZENE	17	0	0	.	*	.	.	*	.

Table V-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	14	0	0	.	*	.	.	*	.
4-NITROPHENOL	14	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	14	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	14	0	0	.	*	.	.	*	.
N-NITROSODIMETHYLAMINE	17	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	17	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	17	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	14	0	0	.	*	.	.	*	.
PHENOL	14	0	0	.	*	.	.	*	.
BIS(2-ETHYLHEXYL) PHTHALATE	17	10	8	3	3	10	21	46	62
BUTYL BENZYL PHTHALATE	17	0	0	.	*	.	.	*	.
DI-N-BUTYL PHTHALATE	17	8	3	2	*	3	5	*	11
DI-N-OCTYL PHTHALATE	17	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	17	5	1	1	*	2	6	*	23
DIMETHYL PHTHALATE	17	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	14	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	17	3	0	1	*	1	1	*	2
BENZO(B)FLUORANTHENE	17	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	17	3	2	1	*	4	6	*	11
CHRYSENE	14	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	17	0	0	.	*	.	.	*	.
ANTHRACENE	14	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	17	3	0	1	*	4	6	*	10
FLUORENE	17	1	0	1	*	1	1	*	1
PHENANTHRENE	14	1	1	12	*	12	12	*	12
DIBENZO(A,H)ANTHRACENE	17	2	0	6	*	6	8	*	10
INDENO(1,2,3-C,D)PYRENE	17	2	0	7	*	7	8	*	10
PYRENE	17	1	0	1	*	1	1	*	1

Table V-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	18	0	0	.	*	.	.	*	.
TOLUENE	18	7	4	2	*	10	15	*	45
TRICHLOROETHYLENE	18	0	0	.	*	.	.	*	.
VINYL CHLORIDE	18	0	0	.	*	.	.	*	.
ALDRIN	14	0	0	.	*	.	.	*	.
DIELDRIN	14	0	0	.	*	.	.	*	.
CHLORDANE	14	0	0	.	*	.	.	*	.
4,4-DDT	14	0	0	.	*	.	.	*	.
4,4-DDE	14	0	0	.	*	.	.	*	.
4,4-DDD	14	0	0	.	*	.	.	*	.
ENDOSULFAN-ALPHA	14	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	14	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	14	0	0	.	*	.	.	*	.
ENDRIN	14	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	14	0	0	.	*	.	.	*	.
HEPTACHLOR	14	0	0	.	*	.	.	*	.
HEPTACHLOR EPOXIDE	14	1	0	2.24	*	2.24	2.24	*	2.24
BHC-ALPHA	14	0	0	.	*	.	.	*	.
BHC-BETA	14	1	0	2.24	*	2.24	2.24	*	2.24
BHC (LINDANE)-GAMMA	14	1	0	2.24	*	2.24	2.24	*	2.24
BHC-DELTA	14	0	0	.	*	.	.	*	.
PCB-1242 (AROCHLOR 1242)	14	1	0	2.24	*	2.24	2.24	*	2.24
PCB-1254 (AROCHLOR 1254)	14	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	14	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	14	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	14	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	14	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	14	0	0	.	*	.	.	*	.

Table V-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	14	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	17	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	14	3	2	2	*	8	15	*	28
BENZO(A)ANTHRACENE/CHRYSENE	5	1	0	1	*	1	1	*	1
BENZO(3,4/K)FLUORANTHENE	2	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	22	9	1	1	*	2	5	*	26
ARSENIC (TOTAL)	23	13	8	2	2	23	89	189	510
BERYLLIUM (TOTAL)	23	7	4	7	*	12	18	*	34
CADMIUM (TOTAL)	23	3	2	10	*	11	40	*	98
CHROMIUM (TOTAL)	23	11	11	14	14	47	126	177	780
COPPER (TOTAL)	23	17	15	5	7	29	133	174	1290
CYANIDE (TOTAL)	18	0	0	.	*	.	.	*	.
LEAD (TOTAL)	23	6	5	8	*	27	147	*	405
MERCURY (TOTAL)	23	12	0	0.40	0.46	1.30	1.73	3.14	4.10
NICKEL (TOTAL)	23	13	13	23	28	125	469	1000	2020
SELENIUM (TOTAL)	23	12	7	2	2	17	25	55	59
SILVER (TOTAL)	23	10	7	4	4	11	14	29	31
THALLIUM (TOTAL)	23	7	2	1	*	1	4	*	14
ZINC (TOTAL)	23	21	21	11	29	420	932	2209	6620

Table V-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ACID DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS		DETECTED CONCENTRATIONS IN UG/L				
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	23	22	9800	11040	65000	1033E4	2964E3	2180E5
PH (UNITS)	25	25	2.5	3.2	5.9	5.6	7.9	8.0
IRON (TOTAL)	23	23	77	588	12387	198222	217500	2790E3
MANGANESE (TOTAL)	23	22	22	283	4300	8323	12400	63000
ASBESTOS(TOTAL-FIBERS/LITER)	2	1	3500E3	*	3500E3	3500E3	*	3500E3
COD	18	15	5100	9050	43150	6027E3	919999	8800E4
DISSOLVED SOLIDS	14	14	71000	71800	450000	655762	1537E3	2130E3
TOTAL VOLATILE SOLIDS	11	11	30000	31200	320250	512818	1252E3	1400E3
VOLATILE SUSPENDED SOLIDS	7	6	1400	*	4000	153100	*	890000
SETTLEABLE SOLIDS	13	9	0.0	*	1.0	70.8	*	600.0
TOTAL ORGANIC CARBON	18	17	280	430	9150	289621	189200	4410E3
FREE ACIDITY (CACO3)	5	5	19000	*	34500	69800	*	160000
MO ALKALINITY (CACO3)	9	9	10	*	39000	54890	*	120000
PHENOLICS(4AAP)	18	1	8	*	8	8	*	8
SULFATE	7	7	130000	*	578333	709524	*	1530E3
TOTAL SOLIDS	11	11	370000	378000	3800E3	3739E3	6740E3	8200E3

Table V-6

WASTEWATER CHARACTERIZATION SUMMAR.
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	21	0	0	.	*	.	.	*	.
ACROLEIN	20	0	0	.	*	.	.	*	.
ACRYLONITRILE	20	0	0	.	*	.	.	*	.
BENZENE	20	3	1	3	*	3	28	*	73
BENZIDENE	21	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	20	0	0	.	*	.	.	*	.
CHLOROBENZENE	19	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	21	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	21	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	20	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	20	2	0	3	*	3	3	*	3
HEXACHLOROETHANE	21	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	20	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	20	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	20	0	0	.	*	.	.	*	.
CHLOROETHANE	20	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	20	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	21	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	20	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	21	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	21	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	21	0	0	.	*	.	.	*	.
CHLOROFORM	20	12	10	3	5	32	76	126	468
2-CHLOROPHENOL	21	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	21	2	1	3	*	3	11	*	18
1,3-DICHLOROBENZENE	21	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	21	1	0	3	*	3	3	*	3
3,3-DICHLOROBENZIDINE	21	0	0	.	*	.	.	*	.

Table V-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	20	3	0	3	*	3	3	*	3
1,2-TRANS-DICHLOROETHYLENE	20	0	0	.	*	.	.	*	.
2,4-DICHLOROPHENOL	21	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	20	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	20	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	21	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	21	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	21	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	21	0	0	.	*	.	.	*	.
ETHYLBENZENE	20	1	1	11	*	11	11	*	11
FLUORANTHENE	21	0	0	.	*	.	.	*	.
4-CHLOROPHENYL PHENYL ETHER	21	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	21	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	21	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	21	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	20	19	13	3	3	533	1152	2453	8984
METHYL CHLORIDE	20	0	0	.	*	.	.	*	.
METHYL BROMIDE	20	0	0	.	*	.	.	*	.
BROMOFORM	20	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	20	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	20	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	20	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	20	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	21	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	21	0	0	.	*	.	.	*	.
ISOPHORONE	21	0	0	.	*	.	.	*	.
NAPHTHALENE	21	1	1	11	*	11	11	*	11
NITROBENZENE	21	0	0	.	*	.	.	*	.

Table V-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	20	0	0	.	*	.	.	*	.
TOLUENE	20	3	3	11	*	28	30	*	40
TRICHLOROETHYLENE	20	0	0	.	*	.	.	*	.
VINYL CHLORIDE	20	0	0	.	*	.	.	*	.
ALDRIN	21	0	0	.	*	.	.	*	.
DIELDRIN	21	0	0	.	*	.	.	*	.
CHLORDANE	21	0	0	.	*	.	.	*	.
4,4-DDT	21	0	0	.	*	.	.	*	.
4,4-DDE	21	0	0	.	*	.	.	*	.
4,4-DDD	21	0	0	.	*	.	.	*	.
ENDOSULFAN-ALPHA	21	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	21	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	21	0	0	.	*	.	.	*	.
ENDRIN	21	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	21	0	0	.	*	.	.	*	.
HEPTACHLOR	21	0	0	.	*	.	.	*	.
HEPTACHLOR EPOXIDE	21	0	0	.	*	.	.	*	.
BHC-ALPHA	21	0	0	.	*	.	.	*	.
BHC-BETA	21	1	0	1.10	*	1.10	1.10	*	1.10
BHC (LINDANE)-GAMMA	21	1	0	0.40	*	0.40	0.40	*	0.40
BHC-DELTA	21	2	0	2.24	*	2.24	2.24	*	2.24
PCB-1242 (AROCHLOR 1242)	21	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	21	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	21	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	21	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	21	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	21	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	21	0	0	.	*	.	.	*	.

Table V-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	21	0	0	.	*	.	.	*	.
4-NITROPHENOL	21	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	21	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	21	0	0	.	*	.	.	*	.
N-NITROSODIMETHYLAMINE	21	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	21	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	21	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	21	0	0	.	*	.	.	*	.
PHENOL	21	2	0	3	*	3	3	*	3
BIS(2-ETHYLHEXYL) PHTHALATE	21	4	1	3	*	3	6	*	14
BUTYL BENZYL PHTHALATE	21	1	0	3	*	3	3	*	3
DI-N-BUTYL PHTHALATE	21	8	0	3	*	3	3	*	3
DI-N-OCTYL PHTHALATE	21	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	21	2	0	3	*	3	3	*	3
DIMETHYL PHTHALATE	21	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	21	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	21	0	0	.	*	.	.	*	.
BENZO(B)FLUORANTHENE	21	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	21	0	0	.	*	.	.	*	.
CHRYSENE	21	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	21	0	0	.	*	.	.	*	.
ANTHRACENE	21	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	21	1	0	3	*	3	3	*	3
FLUORENE	21	0	0	.	*	.	.	*	.
PHENANTHRENE	21	0	0	.	*	.	.	*	.
DIBENZO(A,H)ANTHRACENE	21	1	0	3	*	3	3	*	3
INDENO(1,2,3-C,D)PYRENE	21	1	0	3	*	3	3	*	3
PYRENE	21	0	0	.	*	.	.	*	.

Table V-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	21	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	21	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	20	1	0	3	*	3	3	*	3
BENZO(A)ANTHRACENE/CHRYSENE	7	0	0	.	*	.	.	*	.
BENZO(3,4/K)FLUORANTHENE	7	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	44	14	4	1	1	3	7	18	27
ARSENIC (TOTAL)	44	16	2	2	2	4	11	21	72
BERYLLIUM (TOTAL)	44	4	0	0	*	1	1	*	2
CADMIUM (TOTAL)	44	6	5	6	*	15	14	*	21
CHROMIUM (TOTAL)	44	23	21	8	9	39	43	65	109
COPPER (TOTAL)	44	24	12	4	5	10	13	28	42
CYANIDE (TOTAL)	28	3	0	2	*	4	6	*	8
LEAD (TOTAL)	44	15	8	2	2	15	33	80	94
MERCURY (TOTAL)	44	20	1	0.27	0.30	0.55	1.47	1.87	13.00
NICKEL (TOTAL)	44	13	13	30	30	62	88	170	365
SELENIUM (TOTAL)	44	11	2	2	2	3	20	23	160
SILVER (TOTAL)	44	8	5	10	*	13	14	*	22
THALLIUM (TOTAL)	44	7	2	1	*	2	6	*	23
ZINC (TOTAL)	44	35	32	7	11	50	91	133	1100

Table V-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	40	40	500	1600	16400	80675	209999	871000
PH (UNITS)	40	40	6.3	7.0	7.8	7.8	8.3	9.4
IRON (TOTAL)	44	43	11	113	384	1842	2710	39040
MANGANESE (TOTAL)	43	35	3	8	142	526	923	7000
ASBESTOS(TOTAL-FIBERS/LITER)	7	7	3300E4	*	1090E6	1132E7	*	4100E7
COD	28	28	40	7000	17200	156620	89867	3260E3
DISSOLVED SOLIDS	16	16	85000	203200	880000	1315E3	2940E3	3200E3
TOTAL VOLATILE SOLIDS	20	19	10000	51700	136500	3785E3	681586	6700E4
VOLATILE SUSPENDED SOLIDS	15	10	1000	1000	2800	24280	12000	200000
SETTLEABLE SOLIDS	24	20	0.0	0.0	0.1	99.0	10.0	1800.0
TOTAL ORGANIC CARBON	27	22	5533	6800	10833	32770	57407	133000
MO ALKALINITY (CACO3)	17	17	40000	82000	295000	331353	583000	600000
PHENOLICS(4AAP)	27	6	2	*	16	18	*	40
TOTAL ACIDITY (CACO3)	1	1	10500	*	10500	10500	*	10500
TOTAL SOLIDS	18	18	260000	268000	920000	1188E4	3292E3	1800E5

most cleaning operations, this separation of impurities is based on a specific gravity difference between less dense coal and heavier contaminants such as sulfur, ash, and rock. Sulfur occurs in a coal seam in three forms: as pyrites, in organic compounds, and as sulfate. In coal, the sulfur contribution from sulfate is almost always negligible. The total sulfur content may vary from less than one percent to over eight percent; most bituminous coals are in the two to five percent range.

The total sulfur content distribution between the organic and pyritic forms ranges from 5 to 60 percent and 40 to 95 percent, respectively. Organic sulfur in coal is chemically bound and requires a chemical extraction process for removal; physical coal cleaning is restricted to removal of ash, refuse, and the pyritic sulfur (FeS_2) from coal. In the physical cleaning processes, water is most often used to assist in the removal of unwanted components. The water consumption and usage in a preparation plant was discussed in the previous section. Effluents are most often laden with suspended coal and refuse fines. This slurry is generally dewatered by mechanical or thermal drying equipment internal to the preparation plant, with the water recycled and the partially dewatered, solids-laden slurry discharged to a dewatering and slurry treatment system. Clarified water from this section can often be recycled to the preparation plant to reduce makeup water needs as well as lessen the quantity of final discharge to a receiving stream.

Facilities 00003 through 00005, 00007, 00008, 00011 through 00014, 00017, 00019 through 00022, 00024, and 00025 were sampled during the screening phase of sampling. During verification, preparation plants 00011, 00021 and 00025 were revisited and sampled and facilities 00018 and 00023 were sampled for the first time. Engineering site visits were conducted at preparation plants 00032 through 00035. Analytical results of the untreated wastewater for each of these facilities are summarized on Table V-7, with the raw data in Appendix B of the Proposed Coal Mining Development Document (EPA 440/1-81/057-b). The flow charts and a description for each facility may be found in Appendix F in the Proposed Coal Mining Development. The high metals concentrations are the result of coal and refuse fines found in a preparation process slurry effluent. The suspended solids levels in some of these slurries can be quite high if no fines recovery or removal is practiced.

Preparation Plant Associated Areas

The principal source of drainage in preparation plant associated areas is precipitation-induced runoff. Three areas generating drainage can be delineated as follows: 1. Coal storage piles 2. Refuse piles 3. Other disturbed areas.

Coal Storage Piles

The quantity and quality of wastewater generated by drainage through a coal storage pile are highly variable, depending upon rainfall

Table V-7

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	7	3	0	3	*	3	3	*	3
ACROLEIN	7	0	0	.	*	.	.	*	.
ACRYLONITRILE	7	0	0	.	*	.	.	*	.
BENZENE	7	2	1	3	*	3	9	*	15
BENZIDENE	7	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	7	0	0	.	*	.	.	*	.
CHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	7	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	7	2	1	3	*	3	13	*	23
HEXACHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	7	0	0	.	*	.	.	*	.
CHLOROETHANE	7	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	7	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	7	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	7	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	7	1	0	3	*	3	3	*	3
2,4,6-TRICHLOROPHENOL	7	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	7	0	0	.	*	.	.	*	.
CHLOROFORM	7	2	1	5	*	5	17	*	29
2-CHLOROPHENOL	7	1	1	88	*	88	88	*	88
1,2-DICHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,3-DICHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	7	0	0	.	*	.	.	*	.
3,3-DICHLOROBENZIDINE	7	0	0	.	*	.	.	*	.

Table V-7 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	7	0	0	.	*	.	.	*	.
1,2-TRANS-DICHLOROETHYLENE	7	0	0	.	*	.	.	*	.
2,4-DICHLOROPHENOL	7	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	7	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	7	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	7	3	3	18	*	20	21	*	24
2,4-DINITROTOLUENE	7	1	1	18	*	18	18	*	18
2,6-DINITROTOLUENE	7	1	1	30	*	30	30	*	30
1,2-DIPHENYLHYDRAZINE	7	1	0	3	*	3	3	*	3
ETHYLBENZENE	7	1	0	3	*	3	3	*	3
FLUORANTHENE	7	5	2	3	*	3	6	*	11
4-CHLOROPHENYL PHENYL ETHER	7	1	0	3	*	3	3	*	3
4-BROMOPHENYL PHENYL ETHER	7	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	7	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	7	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	7	4	2	3	*	7	125	*	292
METHYL CHLORIDE	7	0	0	.	*	.	.	*	.
METHYL BROMIDE	7	0	0	.	*	.	.	*	.
BROMOFORM	7	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	7	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	7	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	7	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	7	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	7	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	7	0	0	.	*	.	.	*	.
ISOPHORONE	7	1	1	307	*	307	307	*	307
NAPHTHALENE	7	6	4	3	*	43	121	*	410
NITROBENZENE	7	1	1	21	*	21	21	*	21

Table V-7 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	7	1	1	17	*	17	17	*	17
4-NITROPHENOL	7	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	7	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	7	1	1	194	*	194	194	*	194
N-NITROSODIMETHYLAMINE	7	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	7	1	1	45	*	45	45	*	45
N-NITROSODI-N-PROPYLAMINE	7	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	7	0	0	.	*	.	.	*	.
PHENOL	7	4	1	3	*	3	6	*	16
BIS(2-ETHYLHEXYL) PHTHALATE	7	5	3	3	*	6	19	*	48
BUTYL BENZYL PHTHALATE	7	3	0	3	*	3	3	*	3
DI-N-BUTYL PHTHALATE	7	5	0	3	*	3	3	*	3
DI-N-OCTYL PHTHALATE	7	1	0	3	*	3	3	*	3
DIETHYL PHTHALATE	7	4	0	3	*	3	3	*	3
DIMETHYL PHTHALATE	7	1	0	3	*	3	3	*	3
BENZO(A)ANTHRACENE	7	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	7	4	2	3	*	3	40	*	141
BENZO(B)FLUORANTHENE	7	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	7	0	0	.	*	.	.	*	.
CHRYSENE	7	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	7	1	1	9	*	9	9	*	9
ANTHRACENE	7	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	7	3	1	3	*	3	4	*	7
FLUORENE	7	4	2	3	*	3	17	*	44
PHENANTHRENE	7	0	0	.	*	.	.	*	.
DIBENZO(A,H)ANTHRACENE	7	2	0	3	*	3	3	*	3
INDENO(1,2,3-C,D)PYRENE	7	1	0	3	*	3	3	*	3
PYRENE	7	5	2	3	*	3	10	*	25

Table V-7 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	7	0	0	.	*	.	.	*	.
TOLUENE	7	3	1	3	*	3	5	*	9
TRICHLOROETHYLENE	7	1	0	3	*	3	3	*	3
VINYL CHLORIDE	7	0	0	.	*	.	.	*	.
ALDRIN	6	1	0	6.40	*	6.40	6.40	*	6.40
DIELDRIN	6	3	0	2.24	*	2.24	2.28	*	2.30
CHLORDANE	7	0	0	.	*	.	.	*	.
4,4-DDT	6	0	0	.	*	.	.	*	.
4,4-DDE	6	1	0	2.24	*	2.24	2.24	*	2.24
4,4-DDD	6	1	0	2.24	*	2.24	2.24	*	2.24
ENDOSULFAN-ALPHA	6	3	0	0.10	*	1.17	1.52	*	2.24
ENDOSULFAN-BETA	6	2	0	2.24	*	2.24	2.24	*	2.24
ENDOSULFAN SULFATE	7	0	0	.	*	.	.	*	.
ENDRIN	7	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	6	2	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR	6	1	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR EPOXIDE	6	3	0	0.20	*	1.22	1.56	*	2.24
BHC-ALPHA	6	3	0	2.24	*	2.24	2.36	*	2.60
BHC-BETA	6	3	0	1.40	*	1.82	1.98	*	2.24
BHC (LINDANE)-GAMMA	6	3	0	0.43	*	1.33	1.63	*	2.24
BHC-DELTA	6	3	0	0.23	*	1.23	1.57	*	2.24
PCB-1242 (AROCHLOR 1242)	7	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	7	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	7	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	7	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	7	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	7	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	7	0	0	.	*	.	.	*	.

Table V-7 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	7	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	7	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	7	6	3	3	*	3	32	*	104
BENZO(A)ANTHRACENE/CHRYSENE	6	5	2	3	*	4	16	*	49
BENZO(3,4/K)FLUORANTHENE	6	3	1	3	*	3	4	*	7
ANTIMONY (TOTAL)	13	6	3	2	*	2	19	*	50
ARSENIC (TOTAL)	13	12	12	37	40	240	1072	2406	6500
BERYLLIUM (TOTAL)	13	9	8	3	*	36	93	*	450
CADMIUM (TOTAL)	13	6	6	13	*	34	102	*	290
CHROMIUM (TOTAL)	13	11	11	29	36	418	1260	2582	7500
COPPER (TOTAL)	13	13	13	100	136	1150	2106	6280	6500
CYANIDE (TOTAL)	7	0	0	.	*	.	.	*	.
LEAD (TOTAL)	13	12	12	24	33	760	1453	4287	5500
MERCURY (TOTAL)	13	7	4	1.00	*	11.25	17.85	*	43.00
NICKEL (TOTAL)	13	10	10	300	300	933	1537	2800	5500
SELENIUM (TOTAL)	13	10	9	3	3	40	137	350	410
SILVER (TOTAL)	13	8	6	6	*	22	29	*	64
THALLIUM (TOTAL)	13	9	4	7	*	9	16	*	31
ZINC (TOTAL)	13	12	12	480	546	2867	4464	9660	13500

Table V-7 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY PREP PLANTS
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	12	12	9131E3	9776E3	3440E4	6244E4	1875E5	2400E5
PH (UNITS)	12	12	4.2	4.7	7.3	7.2	8.0	8.1
IRON (TOTAL)	13	13	70000	77200	876250	825372	1650E3	2300E3
MANGANESE (TOTAL)	13	13	1075	1282	6087	8337	17900	25000
ASBESTOS(TOTAL-FIBERS/LITER)	1	1	5100E6	*	5100E6	5100E6	*	5100E6
COD	7	7	1470E4	*	3430E4	6123E4	*	2220E5
DISSOLVED SOLIDS	5	5	650000	*	1055E3	1372E3	*	2500E3
TOTAL VOLATILE SOLIDS	7	7	7567E3	*	2191E4	2893E4	*	8051E4
VOLATILE SUSPENDED SOLIDS	2	2	2000E3	*	2000E3	1500E4	*	2800E4
SETTLEABLE SOLIDS	11	11	58.3	60.7	224.3	387.4	835.0	880.0
TOTAL ORGANIC CARBON	7	7	1100E3	*	4137E3	8446E3	*	2847E4
MO ALKALINITY (CACO3)	5	5	160000	*	260000	1356E3	*	5400E3
PHENOLICS(4AAP)	7	4	20	*	25	63	*	155
TOTAL SOLIDS	2	2	9600E3	*	9600E3	2380E4	*	3800E4

conditions, pile configuration, and coal quality and size. The phenomena responsible for the formation of acid mine drainage in the active mining area can also operate within the coal storage pile. The outer layer of a coal pile (to a depth of approximately one foot) is subject to slacking. Slacking refers to rapid changes in moisture content brought about by alternating sun and rain. This often opens up fresh surfaces and accelerates oxidation. Although organic leaching rates are very low, specific inorganic coal components, such as calcium, magnesium, and toxic metals may be contained in the wastewater. Erosion of waste coal fragments can result in high suspended solids levels (19). Pollutants can be leached into any water contacting the coal storage pile. The composition of pile drainage is influenced by the residence time of the water within the pile. Precipitation will wash this leachate from the pile, so that contaminant concentrations will decrease with increasing water flow rate, until the time that this flushing is complete.

Refuse Piles

Mining, crushing, and washing processes concentrate the coal impurities in the refuse. Extraneous metals and other minerals are separated from the coal and may appear in refuse pile runoff. As most coal-cleaning methods employ gravity separation, dense materials such as clays, shales, and pyrite will be removed as refuse (13). These will contribute to suspended solids levels in the wastewater, while oxidation of the pyrite will produce acid drainage. Organic sulfur and fine pyrite cannot easily be extracted from coal (12), so that these forms do not contribute as significantly to sulfate formation. The relative acidity and pollutant levels of refuse pile drainage are dependent upon the following:

1. Mineral characteristics of the coal and surrounding strata
2. Extent of refuse compaction
3. Configuration of the refuse pile
4. Type of soil cover
5. Climatology
6. Surface water control practices

Other Disturbed Areas

Other disturbed areas ancillary to the preparation plant are analogous to those associated with mines, e.g., adjacent haul roads. As is the case for mines, suspended solids is the primary pollutant of concern in runoff. Screening samples were collected from associated areas at facilities 00016, 00017, 00018, and 00024. Facility 00018 was resampled during the verification phase. Preparation plant associated areas at facilities 00034, 00038, and 00036 were sampled during the engineering site visits. Descriptions of treatment processes, including sampling points, can be found in Appendix F of the Proposed Coal Mining Development Document (EPA 440/1-81/057-b). A summary of the organic, metal and classical pollutants found during the screening and verification sampling programs appears in Table V-8.

Table V-8

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	4	0	0	.	*	.	.	*	.
ACROLEIN	4	0	0	.	*	.	.	*	.
ACRYLONITRILE	4	0	0	.	*	.	.	*	.
BENZENE	4	2	2	44	*	44	46	*	48
BENZIDENE	4	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	4	0	0	.	*	.	.	*	.
CHLOROBENZENE	4	1	1	12	*	12	12	*	12
1,2,3-TRICHLOROBENZENE	4	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	4	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	4	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	4	0	0	.	*	.	.	*	.
HEXACHLOROETHANE	4	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	4	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	4	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	4	0	0	.	*	.	.	*	.
CHLOROETHANE	4	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	4	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	4	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	4	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	4	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	4	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	4	0	0	.	*	.	.	*	.
CHLOROFORM	4	2	2	45	*	45	281	*	476
2-CHLOROPHENOL	4	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	4	0	0	.	*	.	.	*	.
1,3-DICHLOROBENZENE	4	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	4	0	0	.	*	.	.	*	.
3,3-DICHLOROBENZIDINE	4	0	0	.	*	.	.	*	.

Table V-8 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	4	0	0	.	*	.	.	*	.
1,2-TRANS-DICHLOROETHYLENE	4	0	0	.	*	.	.	*	.
2,4-DICHLOROPHENOL	4	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	4	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	4	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	4	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	4	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	4	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	4	0	0	.	*	.	.	*	.
ETHYLBENZENE	4	0	0	.	*	.	.	*	.
FLUORANTHENE	4	0	0	.	*	.	.	*	.
4-CHLOROPHENYL PHENYL ETHER	4	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	4	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	4	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	4	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	4	4	4	162	*	348	763	*	1440
METHYL CHLORIDE	4	0	0	.	*	.	.	*	.
METHYL BROMIDE	4	0	0	.	*	.	.	*	.
BROMOFORM	4	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	4	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	4	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	4	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	4	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	4	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	4	0	0	.	*	.	.	*	.
ISOPHORONE	4	0	0	.	*	.	.	*	.
NAPHTHALENE	4	0	0	.	*	.	.	*	.
NITROBENZENE	4	0	0	.	*	.	.	*	.

Table V-8 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	4	0	0	.	*	.	.	*	.
4-NITROPHENOL	4	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	4	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	4	0	0	.	*	.	.	*	.
N-NITROSODIMETHYLAMINE	4	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	4	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	4	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	4	0	0	.	*	.	.	*	.
PHENOL	4	0	0	.	*	.	.	*	.
BIS(2-ETHYLHEXYL) PHTHALATE	4	2	0	3	*	3	7	*	10
BUTYL BENZYL PHTHALATE	4	0	0	.	*	.	.	*	.
DI-N-BUTYL PHTHALATE	4	0	0	.	*	.	.	*	.
DI-N-OCTYL PHTHALATE	4	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	4	0	0	.	*	.	.	*	.
DIMETHYL PHTHALATE	4	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	4	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	4	0	0	.	*	.	.	*	.
BENZO(B)FLUORANTHENE	4	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	4	0	0	.	*	.	.	*	.
CHRYSENE	4	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	4	0	0	.	*	.	.	*	.
ANTHRACENE	4	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	4	0	0	.	*	.	.	*	.
FLUORENE	4	0	0	.	*	.	.	*	.
PHENANTHRENE	4	0	0	.	*	.	.	*	.
DIBENZO(A,H)ANTHRACENE	4	0	0	.	*	.	.	*	.
INDENO(1,2,3-C,D)PYRENE	4	0	0	.	*	.	.	*	.
PYRENE	4	0	0	.	*	.	.	*	.

Table V-8 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	4	0	0	.	*	.	.	*	.
TOLUENE	4	3	2	10	*	12	17	*	27
TRICHLOROETHYLENE	4	0	0	.	*	.	.	*	.
VINYL CHLORIDE	4	0	0	.	*	.	.	*	.
ALDRIN	4	0	0	.	*	.	.	*	.
DIELDRIN	4	0	0	.	*	.	.	*	.
CHLORDANE	4	0	0	.	*	.	.	*	.
4,4-DDT	4	0	0	.	*	.	.	*	.
4,4-DDE	4	0	0	.	*	.	.	*	.
4,4-DDD	4	0	0	.	*	.	.	*	.
ENDOSULFAN-ALPHA	4	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	4	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	4	0	0	.	*	.	.	*	.
ENDRIN	4	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	4	0	0	.	*	.	.	*	.
HEPTACHLOR	4	0	0	.	*	.	.	*	.
HEPTACHLOR EPOXIDE	4	0	0	.	*	.	.	*	.
BHC-ALPHA	4	0	0	.	*	.	.	*	.
BHC-BETA	4	1	0	0.33	*	0.33	0.33	*	0.33
BHC (LINDANE)-GAMMA	4	0	0	.	*	.	.	*	.
BHC-DELTA	4	1	0	0.10	*	0.10	0.10	*	0.10
PCB-1242 (AROCHLOR 1242)	4	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	4	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	4	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	4	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	4	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	4	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	4	0	0	.	*	.	.	*	.

Table V-8 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	4	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	4	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	4	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE/CHRYSENE	1	0	0	.	*	.	.	*	.
BENZO(3,4/K)FLUORANTHENE	1	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	9	3	1	2	*	5	13	*	28
ARSENIC (TOTAL)	9	4	2	2	*	3	350	*	1340
BERYLLIUM (TOTAL)	9	4	2	2	*	4	60	*	220
CADMIUM (TOTAL)	9	3	3	13	*	18	25	*	38
CHROMIUM (TOTAL)	9	7	6	10	*	61	235	*	980
COPPER (TOTAL)	9	7	5	6	*	44	232	*	1000
CYANIDE (TOTAL)	4	0	0	.	*	.	.	*	.
LEAD (TOTAL)	9	4	3	3	*	30	271	*	1000
MERCURY (TOTAL)	9	4	0	0.20	*	0.70	1.10	*	2.40
NICKEL (TOTAL)	9	7	7	38	*	232	1771	*	10000
SELENIUM (TOTAL)	9	4	3	1	*	21	137	*	450
SILVER (TOTAL)	9	2	2	27	*	27	31	*	38
THALLIUM (TOTAL)	9	1	1	14	*	14	14	*	14
ZINC (TOTAL)	9	8	8	19	*	240	4287	*	30000

Table V-8 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ASSOCIATED AREAS
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	7	7	3300	*	20200	87084	*	240000
PH (UNITS)	7	7	2.4	*	5.8	5.4	*	7.2
IRON (TOTAL)	9	9	275	*	3700	1246E3	*	9000E3
MANGANESE (TOTAL)	9	9	27	*	2237	17438	*	80000
COD	4	4	12675	*	15500	362044	*	1160E3
DISSOLVED SOLIDS	3	3	580000	*	1390E3	1960E3	*	3100E3
TOTAL VOLATILE SOLIDS	4	4	26000	*	64250	1398E3	*	2900E3
VOLATILE SUSPENDED SOLIDS	4	4	2200	*	4800	10250	*	28000
SETTLEABLE SOLIDS	3	2	0.0	*	0.0	0.0	*	0.0
TOTAL ORGANIC CARBON	4	3	4125	*	7812	11508	*	19300
FREE ACIDITY (CACO3)	1	1	740000	*	740000	740000	*	740000
MO ALKALINITY (CACO3)	2	2	1000	*	1000	21500	*	42000
PHENOLICS(4AAP)	4	0	.	*	.	.	*	.
SULFATE	1	1	310000	*	310000	310000	*	310000
TOTAL SOLIDS	4	4	180000	*	410000	9147E3	*	2200E4

Post Mining Discharges

Reclamation Areas

Reclamation areas are tracts of surface acreage which have been recontoured and seeded to establish ground cover after mining has ceased. Regrading has already been completed by removal of the spoil peaks and reestablishment of natural drainageways. Replanting of indigenous grasses, legumes, and other annual or perrenial flora occurs as soon as possible to stabilize the regraded area. Runoff from this area directly following active mining can exhibit substantial suspended solids loadings until vegetation is well established. Data from a self-monitoring survey initiated by the Agency are presented in Table V-9. These data are from facilities 00015, 00033, 00037, 00085, 00101, and 00181 through 00187. Also included in Table V-9 are data from facility 00033 sampled during the engineering site visits. As shown on the table, suspended solids loadings are substantial. This is particularly true for rainfall conditions.

Underground Mines

Discharges from underground mines will continue after the temporary or permanent cessation of mining until appropriate mine closure procedures are implemented. This is because the principal source of water is from aquifers that were intercepted during mine development. These waste-bearing strata will continue to drain water into the mine during and after the production of coal. A study was conducted to characterize these discharges from active and abandoned anthracite underground mines (21). The results of the study indicate that these discharges will be similar to the wastewaters encountered during active mining. For instance, an active discharge and an adjacent abandoned discharge from one mining operation exhibited similar characteristics. The reader is referenced to the active mine drainage tables (Tables V-5 and V-6) for more detailed characterization of post mining discharges from underground mines.

SUPPORT FOR THE SUBCATEGORIZATION SCHEME

In light of the data characterizing raw wastewater, this subsection will discuss the evolution of the final BPT, BAT, and NSPS subcategorization schemes already presented at the beginning of this section. Preliminary analysis of the results of the BAT screening and verification program (conducted from 1977 to 1979) suggested a number of changes to the BPT categorization. Some of these changes were retained, while others were eliminated based on additional data.

Table V-9

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY AREAS UNDER RECLAMATION
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ANTIMONY (TOTAL)	15	13	13	68	88	101	117	186	235
ARSENIC (TOTAL)	15	4	4	66	*	79	328	*	890
BERYLLIUM (TOTAL)	15	8	3	1	*	4	6	*	12
CADMIUM (TOTAL)	15	6	6	11	*	16	19	*	40
CHROMIUM (TOTAL)	15	12	9	6	8	17	37	101	116
COPPER (TOTAL)	15	14	13	6	8	19	44	114	131
LEAD (TOTAL)	15	4	4	30	*	37	59	*	103
MERCURY (TOTAL)	15	1	1	40.00	*	40.00	40.00	*	40.00
NICKEL (TOTAL)	15	8	8	45	*	85	258	*	996
SELENIUM (TOTAL)	15	2	2	70	*	70	74	*	77
SILVER (TOTAL)	15	4	0	5	*	5	5	*	6
THALLIUM (TOTAL)	15	3	3	147	*	149	161	*	184
ZINC (TOTAL)	15	15	15	7	10	71	1160	1828	12644

Table V-9 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY AREAS UNDER RECLAMATION
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	MIN	DETECTED CONCENTRATIONS IN UG/L				
				10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	16	16	12733	12859	72139	338101	987480	1845E3
PH (UNITS)	16	16	5.1	5.9	7.5	7.3	7.9	8.0
IRON (TOTAL)	16	16	241	505	2365	12655	35550	65683
MANGANESE (TOTAL)	15	15	94	94	390	1407	1770	11805
SETTLEABLE SOLIDS	14	11	0.0	0.0	0.3	4.8	6.0	39.0

First, surface and underground mines were categorized separately for both acid and alkaline mines. In addition to differences in raw wastewater characteristics, this separation resulted from differences in the type of treatment technology that would be applied at surface and deep mines. For instance, mobile or skid mounted treatment processes might often be required at surface mines where current treatment facilities (i.e., sedimentation ponds and possibly neutralization equipment) frequently require relocation. At underground facilities, permanent treatment facilities can usually be installed for the life of the mine.

Second, although separate subcategories for preparation plants and preparation plant associated areas were not established, separate subsets of this category were formed only for NSPS because of the different types of wastewater handling techniques available to the two areas.

Third, post mining discharges were established as a subcategory to provide regulatory coverage for two subsets of this subcategory: surface reclamation areas and underground mine discharges.

Fourth, Pennsylvania anthracite mines were identified as a candidate subcategory based on potential differences in toxic pollutant discharges by different ranks of coal.

Fifth, western mines were separately categorized because of the potential effects of different climatology and coal seams on mine discharges. These modifications resulted in the following preliminary subcategorization scheme:

1. Acid drainage surface mines
2. Acid drainage underground mines
3. Alkaline drainage surface mines
4. Alkaline drainage underground mines
5. Preparation plants and associated areas
   a. Preparation Plants
   b. Preparation associated areas
6. Post mining discharges
   a. Surface reclamation areas
   b. Underground mines
7. Pennsylvania anthracite
8. Western mines

These subcategories were then reviewed by consideration of (1) the engineering principles involved, and (2) the data collected from BAT sampling programs conducted after the screening and verification effort. The following discussion presents the results of this review for each subcategory.

Surface and Underground Mines

Two factors were utilized to establish the surface/underground distinction: (1) differences in raw wastewater characteristics and

(2) differences in the mobility of applicable treatment options. Both of these are rendered academic, however, because of the reduction achieved by application of existing (BPT) technology. When the untreated discharges from deep and surface are subjected to BPT treatment, the resulting effluent are very similar in "classical" pollutants (TSS, iron, manganese). Tables V-10 and V-11 illustrate these data for alkaline and acid mines. Although there are substantial differences in the acid and alkaline raw wastewaters from deep and surface mines, these tables indicate the similarity of BPT-treated discharges with respect to these three key pollutants. The similarity of treated effluent also extends to the toxic metals, as can be seen in Table V-12. Because of these factors, separate subcategories for surface and underground mines were not established.

Preparation Plants and Preparation Plant Associated Areas

These two segments of the coal mining category are classified differently for new sources than for existing sources. For new sources, preparation plants and associated areas are subject to different standards based upon differences in the following:

1. TSS and metals concentrations
2. Treatment strategies
3. Water usage requirements
4. Regulatory strategies

A comparison of raw wastewater metals and TSS concentrations in these two subcategories is presented in Table V-13. The preparation plant raw wastewater is much higher in suspended solids, while toxic metals occur more consistently and in higher concentrations than in associated areas runoff. It is not merely the differences in water quality as apparent from the data, but the differences in treatment strategy implied by these data, that support this division. The major contributor to total metals in the preparation plant slurry is suspended metals, due to the nature of the cleaning process. This is evidenced by the data in Table V-14. This indicates that settling of preparation plant slurry will provide substantial removal of toxic metals. Conversely, metals from associated areas are mostly due to the low pH, and thus a different treatment strategy would be selected, i.e., pH adjustment via neutralization. Figure V-2 shows two typical preparation plant water circuits. Although many factors suggest different treatment systems for preparation plants and associated areas, most facilities currently commingle these drainages, as illustrated in the top configuration of Figure V-2.

For new sources, segregated treatment can be designed into the overall wastewater system. The incentives for separate treatment are discussed below. Water management considerations and economics will most often dictate maximizing water recycle. Preparation plants utilize water to assist in cleaning the coal, and thus the water is process water subject to one class of treatment options. Runoff from associated areas is usually not used in coal cleaning, and hence

Table V-10

COMPARISON OF CLASSICAL POLLUTANTS IN ALKALINE SURFACE AND UNDERGROUND MINES

Mean Values (mg/l)

	Raw		Treated	
Pollutant	Surface	Deep	Surface	Deep
TSS	141	40	36	39
Iron	1.52	0.41	1.26	0.68
Manganese	0.82	0.076	0.39	0.29

Table V-11

COMPARISON OF CLASSICAL POLLUTANTS IN ACID SURFACE AND UNDERGROUND MINES

Mean Values (mg/l)

Pollutant	Raw		Treated	
	Surface	Deep	Surface	Deep
TSS	732	158	32	21.1
Iron	45.7	135	1.21	1.72
Manganese	17.7	4.9	2.45	1.27

Table V-12

COMPARISON OF MEDIAN TOXIC METAL CONCENTRATIONS IN ACID AND ALKALINE SURFACE AND UNDERGROUND MINES
(in ug/1)

	Raw				Treated			
	Acid		Alkaline		Acid		Alkaline	
Pollutant	Surface	Deep	Surface	Deep	Surface	Deep	Surface	Deep
Antimony	--	2.5	6	2	8	2.5	6	2
Arsenic	210	23	3	5	11	18	4	4.4
Beryllium	23	12	2	ND	ND	ND	2	ND
Cadmium	98	6	ND	ND	ND	ND	ND	ND
Chromium	187	30	32	49	126	24	33	49
Copper	150	82	10	6	14	13	10	6
Lead	323	51	23	72	ND	102	23	72
Mercury	1.3	0.9	0.4	0.6	0.3	1.0	0.5	0.6
Nickel	2020	400	30	57	95	5	30	57
Selenium	17	34	3.5	3	13	14	3	3
Silver	ND	5	10	ND	ND	5	10	ND
Thallium	ND	1	2	2	2	1	1.5	1.7
Zinc	6620	510	80	56	29	49	70	56

Source: Screening and Verification Data

Table V-13

PREPARATION PLANTS VERSUS ASSOCIATED AREAS
UNTREATED WATER

	Preparation Plants				Associated Areas			
Parameter	Total Samples	Total Detects	Detects >10 ppb	Median* (mg/l)	Total Samples	Total Detects	Detects >10 ppb	Median* (mg/l)
Antimony	11	6	3	.002	8	3	1	.005
Arsenic	11	10	10	.200	8	4	2	.003
Beryllium	11	7	7	.036	8	4	2	.004
Cadmium	11	4	4	.034	8	3	3	.018
Chromium	11	9	9	.502	8	7	6	.061
Copper	11	11	11	.860	8	7	5	.044
Lead	11	10	10	.760	8	4	3	.030
Mercury	11	6	4	.015	8	4	0	
Nickel	11	8	8	.933	8	6	6	.330
Selenium	11	8	7	.050	8	4	3	.021
Silver	11	6	4	.019	8	2	2	.027
Thallium	11	7	4	.010	8	1	1	.014
Zinc	11	10	10	2.9	8	7	7	.266
Iron	11	11	11	841**	8	8	8	1402**
Manganese	11	11	11	8.5**	8	8	8	19**
TSS	10	10		69,330**	6	6		77**
pH (units)	10	10		7.1	6	6		5.1

* This is the median of all values >10 ppb.

** Mean

Sources: Screening and Verification Data;
Engineering Site Visit Data

Table V-14

PREPARATION PLANT PROCESS EFFLUENT TOTAL VERSUS DISSOLVED METALS

	Preparation Plant A (mg/1)		Preparation Plant B (mg/1)		Preparation Plant C (mg/1)	
	Total Metals	Dissolved Metals	Total Metals	Dissolved Metals	Total Metals	Dissolved Metals
Antimony	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Arsenic	0.037	<0.002	2.7	<0.002	6.5	<0.002
Beryllium	0.016	<0.001	0.012	<0.001	0.016	<0.001
Cadmium	0.034	<0.005	0.29	0.016	0.17	<0.005
Chromium	0.098	0.009	0.92	0.032	0.47	0.013
Copper	0.33	0.006	6.4	0.037	6.0	0.020
Iron	94	0.097	2,300	2.4	1,000	1.0
Lead	0.071	0.003	1.0	<0.002	0.024	<0.002
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	1.7	0.047	13	0.71	12	0.12
Nickel	0.33	0.026	2.8	<0.020	2.1	<0.020
Selenium	<0.005	<0.005	0.21	<0.005	0.35	<0.005
Silver	0.019	0.009	0.064	0.026	0.057	0.019
Thallium	<0.002	<0.002	0.026	<0.002	0.008	<0.002
Zinc	0.98	<0.002	8.3	0.015	6.0	0.007

Source: Engineering Site Visit Data

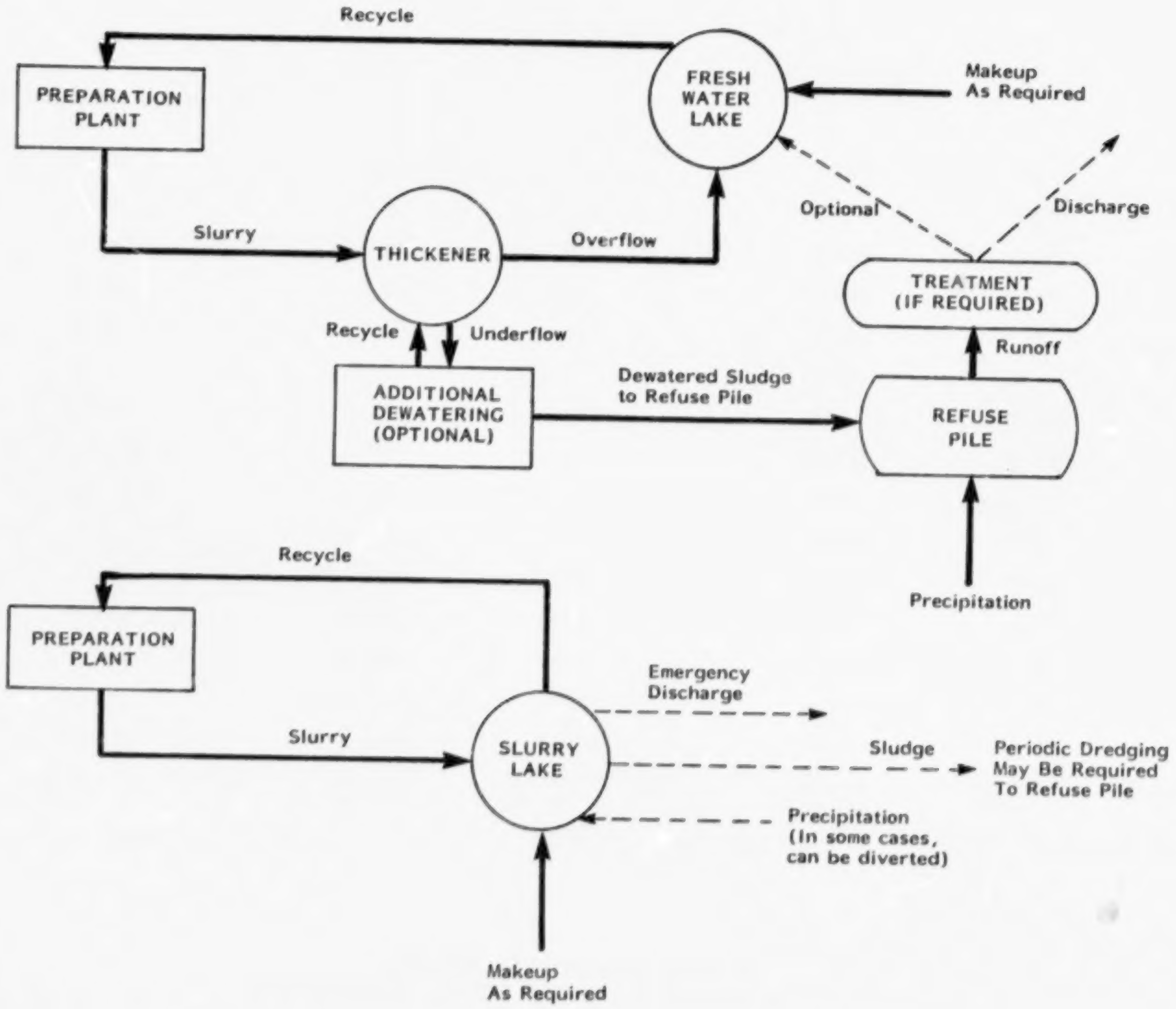

Figure V-2. Typical Preparation Plant Water Circuits

different wastewater treatment strategies are suggested. For instance, the intermittent runoff generated in associated areas is suited to a sedimentation pond system with possible neutralization required if this runoff is acidic. On the other hand, a preparation plant continually discharges process wastewater from the coal cleaning equipment while the plant is operating. This continuous effluent is usually alkaline and solids laden and is thus suited for a settling and decant recycle system. Slurry impoundments could also be used; the flow to these would not increase during a rainfall unless surface runoff is also received. This is not the case for associated areas which most often only discharge significant quantities during rainfall events.

Increased regulatory flexibility is provided by separating these segments. This is particularly in reference to the potential for a "zero discharge" or total recycle regulation for preparation plant slurry waters. If the associated area runoff can be segregated from slurry effluent, the water balance can be achieved through diversion ditching and other techniques, thus allowing total water recycle systems for preparation plants. This is more extensively discussed in Sections VII and VIII.

For existing sources, however, these reasons are overridden by consideration of engineering and cost factors. Current practice in the industry is commonly to commingle wastewater from refuse and storage piles (associated areas) with preparation plant process wastewater for treatment. To set differing limitations for the two segments would cause most operators to segregate the two types of drainage, which would require massive expenditures and gross inefficiency for a facility. Installation of extensive retrofit equipment and construction of new ponds would severely impact the capital and human resources of many coal mining operations, without significantly reducing the discharge of toxic pollutants. A further discussion of these factors is presented in Section VII.

Pennsylvania Anthracite Mines

The Agency examined anthracite mining and preparation to assess any statistical or technical differences in wastewater from bituminous and lignite operations. Results shown in Table V-15 indicate that no significant differences exist; thus anthracite facilities will be categorized identically with bituminous and lignite operations.

Post Mining Discharges

Surface and underground mines can continue to discharge polluted wastewater after production from the mine has ceased. For surface mines, this discharge consists of runoff from a previously mined area that has been backfilled, regraded, and revegetated. This process, called reclamation, is an ongoing operation at one area of a mine that occurs simultaneously with active mining of another area. For underground mines, the post-mining discharge results from groundwater

Table V-15

COMPARISON OF ANTHRACITE AND ACID RAW WASTEWATER

	Anthracite Mines			Acid Mines		
Pollutant	Total Number Samples	Total Detects	Median Value (mg/l)	Total Number Samples	Total Detects	Median Value (mg/l)
TSS	5	5	56*	22	21	440*
Iron	5	5	34*	22	22	88*
Manganese	5	5	6.7*	22	21	8.2*
pH (units)	5	5	4.3	24	24	5.3
			(ug/l)			(ug/l)
Sb	5	0	--	21	8	2
As	5	1	26	22	14	31
Be	5	3	7	22	7	10
Cd	5	0	--	22	3	11
Cr	5	4	40	22	11	41
Cu	5	5	20	22	16	48
Pb	5	3	9	22	6	18
Hg	5	0	--	22	11	1.1
Ni	5	5	50	22	11	140
Se	5	0	--	22	11	28
Ag	5	2	11	22	7	13
Tl	5	0	--	22	5	1
Zn	5	5	520	22	20	460

---

*Mean value

infiltration into the mined out areas. This groundwater can originate from breached aquifers or from adjacent abandoned mines.

During active mining, water is usually pumped to the surface for treatment and discharge. After mine closure, this water will continue to drain into the mine workings. Over a period of time, several outcomes are possible. First, a state of equilibrium could occur when the gravity head of the water balances the infiltration pressure. Second, the water could erode and break through mine seals to adjacent active or abandoned mine tunnels. Third, the mine pool could continue to rise until the level reaches ground level, and, should no mine seal be in place, a surface discharge occurs. Fourth, if the mine is sealed, the water can erode and break through the seal, again resulting in a surface discharge.

The post-mining discharges from either a reclamation area at a surface mine or from an abandoned underground mine can contain significant amounts of pollutants. These problems are addressed by SMCRA. The performance based required by SMCRA is not to be released until the SMCRA regulatory authority determines that post-mining pollution problems are abated and can be reasonably expected not to occur. Sufficient data does not exist to support the promulgation of regulations for discharges after release of the SMCRA bond.

Post-mining discharges were not previously regulated by EPA, and so were postulated as a candidate subcategory for BAT and NSPS effluent limitations. To verify this for the final subcategorization, data were gathered from four independent studies. A self monitoring industry survey was initiated at 24 surface mine sites to characterize raw and treated streams from both active mining and reclamation areas. These data are presented in Table V-9. A second study was conducted at eight surface mine sites which classified pond effluents as well as determined the precision and accuracy of measuring settleable solids below 1.0 ml/l. A third study sampled four anthracite mines to collect data on postmining discharges from underground mines. (Among the wastewaters samples, were discharges from underground abandoned mines). The data are contained in a supplement to this report (21) and are also presented in Table V-15.

EPA determined that settleable solids and pH should be regulated for surface mines in the reclamation phase and for active mines during precipitation events. On the other hand, post-mining discharges from underground mines are very similar to wastewater generated during active mining. This is because the mechanism for wastewater generation is identical.

Western Mines

An evaluation of the nature of discharges from western mines has been performed to determine the appropriateness of separately subcategorizing mines in this region (10). Coal mines west of the 100th meridian in the United States were designated as western mines (42 FR 46937, 19 September 1977). Mines in Colorado, Montana, North

Dakota, South Dakota, Utah, and Wyoming (42 FR 21380, 26 April 1977) are included in the western subcategory. These coal regions are depicted in Figure V-3. This subcategory was established because of potential differences in achievable effluent quality between eastern and western mines for a number of reasons.

The West receives substantially less rainfall than the eastern region. Further, evaporation rates are higher primarily because of the lower humidity in the West. These two conditions result in a smaller amount of runoff and high evaporation from settling ponds. Figure V-4 illustrates the location of these areas. Additionally, site-specific conditions such as topography and hydrogeology are potential incentives for separate regulations.

Tables V-16 through V-19 present data from the BAT sampling program for eastern and western raw wastewaters (10). Treated effluent data for the two regions appear in Tables V-20 through V-23. Additional data from discharge monitoring reports (DMRs) are summarized in Table V-24. Information collected from the DMRs indicates that western mines (16 facilities were included) exhibit no discharge 41 percent of the time samples were taken, compared to 19 percent from eastern mines (56 facilities were included). However, as Tables V-20 through V-23 indicate, the final discharge compositions are very similar for eastern and western mines when a discharge did occur.

This similarity in discharges was further verified by a statistical analysis. The purpose of this analysis was to determine, with respect to TSS, whether effluent discharges at Western alkaline mines were statistically different from effluent discharges at Eastern alkaline mines. The data available for the analysis consisted of 68 samples from Eastern mines (22 influent and 46 effluent) and 26 samples from Western mines (11 influent and 15 effluent). The statistical approach used was a "goodness of fit" test, adopted because of the limited number of samples available from Western mines. Under this approach, the more plentiful Eastern mine data is used to define a sample distribution for TSS. A statistical test is then performed to determine how well the Western mine data "fit" into the Eastern mine distribution. The test results show that the distribution of TSS at Western mines is statistically similar to that at Eastern mines. Figure V-5 provides observed and expected frequencies for influent and effluent samples at Western mines.

The expected frequencies are those which one would expect to see if the Western mine data followed the same distribution as the Eastern mine data. The observed frequencies are those which were actually found in the data. These frequencies were calculated by classifiying each value of TSS observed at a Western mine into one of the four quadrants of the TSS distribution established for Eastern mines. The quadrants of a distribution are those areas which divide the data into four equally dense portions. That is, the first quadrant will contain 25 percent of the data, the second quadrant will contain 25 percent of the data and so on. It should be noted that quadrants were established independently for influent and effluent samples. The

Table V-16

EASTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	14	14	2600	3160	17000	67364	170240	330000
PH (UNITS)	14	14	6.6	6.8	7.6	7.6	8.1	8.7
TOTAL IRON	17	17	11	98	537	1094	2590	3500
MANGANESE (TOTAL)	17	17	3	25	475	935	1430	7000

Table V-17

EASTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ANTIMONY (TOTAL)	17	3	0	2	*	2	3	*	6
ARSENIC (TOTAL)	17	4	1	2	*	2	12	*	40
BERYLLIUM (TOTAL)	17	2	0	2	*	2	2	*	2
CADMIUM (TOTAL)	17	3	2	6	*	10	14	*	21
CHROMIUM (TOTAL)	17	10	9	8	8	33	42	65	109
COPPER (TOTAL)	17	4	3	10	*	13	20	*	42
LEAD (TOTAL)	17	8	4	2	*	8	29	*	94
MERCURY (TOTAL)	17	7	0	0.30	*	0.44	1.06	*	2.20
NICKEL (TOTAL)	17	7	7	30	*	67	115	*	365
SELENIUM (TOTAL)	17	4	0	4	*	6	6	*	7
SILVER (TOTAL)	17	6	3	10	*	10	13	*	22
THALLIUM (TOTAL)	17	1	0	2	*	2	2	*	2
ZINC (TOTAL)	17	13	10	7	7	31	52	138	156

Table V-18

WESTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS		DETECTED CONCENTRATIONS IN UG/L				
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	11	11	500	510	65250	153361	292000	871000
PH (UNITS)	11	11	6.9	7.0	7.7	7.7	8.1	8.2
TOTAL IRON	11	11	64	68	1317	4996	5250	39040
MANGANESE (TOTAL)	11	11	4	4	90	172	222	947

Table V-19

WESTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
RAW WASTEWATER
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
ANTIMONY (TOTAL)	11	3	2	6	*	8	14	*	27
ARSENIC (TOTAL)	11	3	0	4	*	4	6	*	8
BERYLLIUM (TOTAL)	11	2	0	0	*	0	1	*	1
CADMIUM (TOTAL)	11	2	2	11	*	11	14	*	17
CHROMIUM (TOTAL)	11	5	4	8	*	44	42	*	57
COPPER (TOTAL)	11	11	6	4	4	10	14	27	36
LEAD (TOTAL)	11	1	0	4	*	4	4	*	4
MERCURY (TOTAL)	11	3	0	0.27	*	0.35	0.70	*	1.40
NICKEL (TOTAL)	11	1	1	174	*	174	174	*	174
SELENIUM (TOTAL)	11	3	0	2	*	2	3	*	3
SILVER (TOTAL)	11	0	0	.	*	.	.	*	.
THALLIUM (TOTAL)	11	0	0	.	*	.	.	*	.
ZINC (TOTAL)	11	10	10	13	13	80	184	186	1100

Table V-20

EASTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ALKALINE DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	30	30	32	2900	17600	27282	73066	118067
PH (UNITS)	30	30	3.2	6.9	7.7	7.5	8.2	8.5
TOTAL IRON	30	29	54	127	565	1301	2820	5100
MANGANESE (TOTAL)	30	29	28	46	326	558	1330	2800

Table V-21

EASTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ANTIMONY (TOTAL)	30	7	1	1	*	2	5	*	15
ARSENIC (TOTAL)	30	13	3	2	2	5	8	13	22
BERYLLIUM (TOTAL)	30	0	0	.	*	.	.	*	.
CADMIUM (TOTAL)	30	5	4	5	*	14	14	*	23
CHROMIUM (TOTAL)	30	20	17	9	10	33	77	63	860
COPPER (TOTAL)	30	8	4	6	*	10	19	*	40
LEAD (TOTAL)	30	5	3	5	*	12	24	*	66
MERCURY (TOTAL)	30	13	0	0.10	0.16	0.50	1.34	1.67	7.98
NICKEL (TOTAL)	30	4	3	10	*	52	68	*	146
SELENIUM (TOTAL)	30	7	1	1	*	2	5	*	20
SILVER (TOTAL)	30	7	7	14	*	20	20	*	25
THALLIUM (TOTAL)	29	2	0	1	*	1	1	*	2
ZINC (TOTAL)	30	19	15	7	9	19	47	103	188

Table V-22

WESTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ALKALINE DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	MIN	DETECTED CONCENTRATIONS IN UG/L 10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	11	11	2400	2720	9650	21724	28893	97000
PH (UNITS)	11	11	7.5	7.5	7.9	8.0	8.4	8.5
TOTAL IRON	11	10	140	140	349	474	1030	1200
MANGANESE (TOTAL)	11	11	17	18	44	103	242	285.

Table V-23

WESTERN MINES
WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ALKALINE DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ANTIMONY (TOTAL)	11	3	2	3	*	7	10	*	15
ARSENIC (TOTAL)	11	3	0	3	*	4	5	*	6
BERYLLIUM (TOTAL)	11	1	0	0	*	0	0	*	0
CADMIUM (TOTAL)	11	1	0	9	*	9	9	*	9
CHROMIUM (TOTAL)	11	4	3	8	*	11	30	*	50
COPPER (TOTAL)	11	7	2	3	*	9	9	*	15
LEAD (TOTAL)	11	3	1	2	*	5	40	*	109
MERCURY (TOTAL)	11	2	0	0,83	*	0,83	1.72	*	2.60
NICKEL (TOTAL)	11	0	0	.	*	.	.	*	.
SELENIUM (TOTAL)	11	1	0	2	*	2	2	*	2
SILVER (TOTAL)	11	0	0	.	*	.	.	*	.
THALLIUM (TOTAL)	11	1	0	1	*	1	1	*	1
ZINC (TOTAL)	10	6	6	14	*	45	63	*	127

Table V-24

COAL MINE DMR DATA
1979 AVERAGE TSS & Fe VALUES*:
ALKALINE EASTERN VS. ALKALINE WESTERN FACILITIES

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Overall Ave. Values 1979
WESTERN **													
TSS (mg/l)													
Ave. Maximum Value	23.9	24.2	37.2	34.9	27.1	19.1	26.3	21.4	23.0	9.8	13.3	15.8	23.0
Ave. Minimum Value	4.2	4.5	7.3	7.3	5.2	7.2	6.4	5.2	4.6	3.3	5.4	6.6	5.6
Ave. Average Value	16.3	15.3	19.8	18.3	14.3	13.4	14.4	11.4	12.2	6.5	8.6	10.7	13.4
Fe (mg/l)													
Ave. Maximum Value	1.02	1.03	1.00	0.88	0.86	0.54	0.75	1.08	0.81	0.58	0.84	0.35	0.81
Ave. Minimum Value	0.36	0.36	0.25	0.10	0.10	0.17	0.28	0.28	0.31	0.19	0.18	0.13	0.23
Ave. Average Value	0.69	0.67	1.27	0.40	0.45	0.34	0.47	0.60	0.45	0.50	0.65	0.24	0.56
EASTERN**													
TSS (mg/l)													
Ave. Maximum Value	27.3	4.4	19.9	20.4	92.5	9.4	18.0	31.1	25.6	81.0	17.9	46.0	32.8
Ave. Minimum Value	5.5	3.8	9.2	22.2	63.2	5.9	17.0	9.2	6.7	3.0	4.1	36.3	15.5
Ave. Average Value	16.3	12.4	11.3	16.0	48.9	11.6	13.5	17.2	11.2	21.8	7.8	27.8	18.0
Fe (mg/l)													
Ave. Maximum Value	1.09	1.0	0.82	0.45	1.79	0.52	1.16	0.80	0.78	0.45	1.00	1.01	0.91
Ave. Minimum Value	0.44	0.22	0.39	0.35	1.5	0.48	1.03	0.56	0.70	0.02	0.30	0.53	0.54
Ave. Average Value	0.65	0.41	0.42	0.35	1.3	0.39	1.0	0.49	0.5	0.73	0.44	0.93	0.63

* Values do not include instances of "No Discharge," "No Reported Values," or violations due to precipitation events.

** Includes data from 10 Western facilities and 10 Eastern facilities.

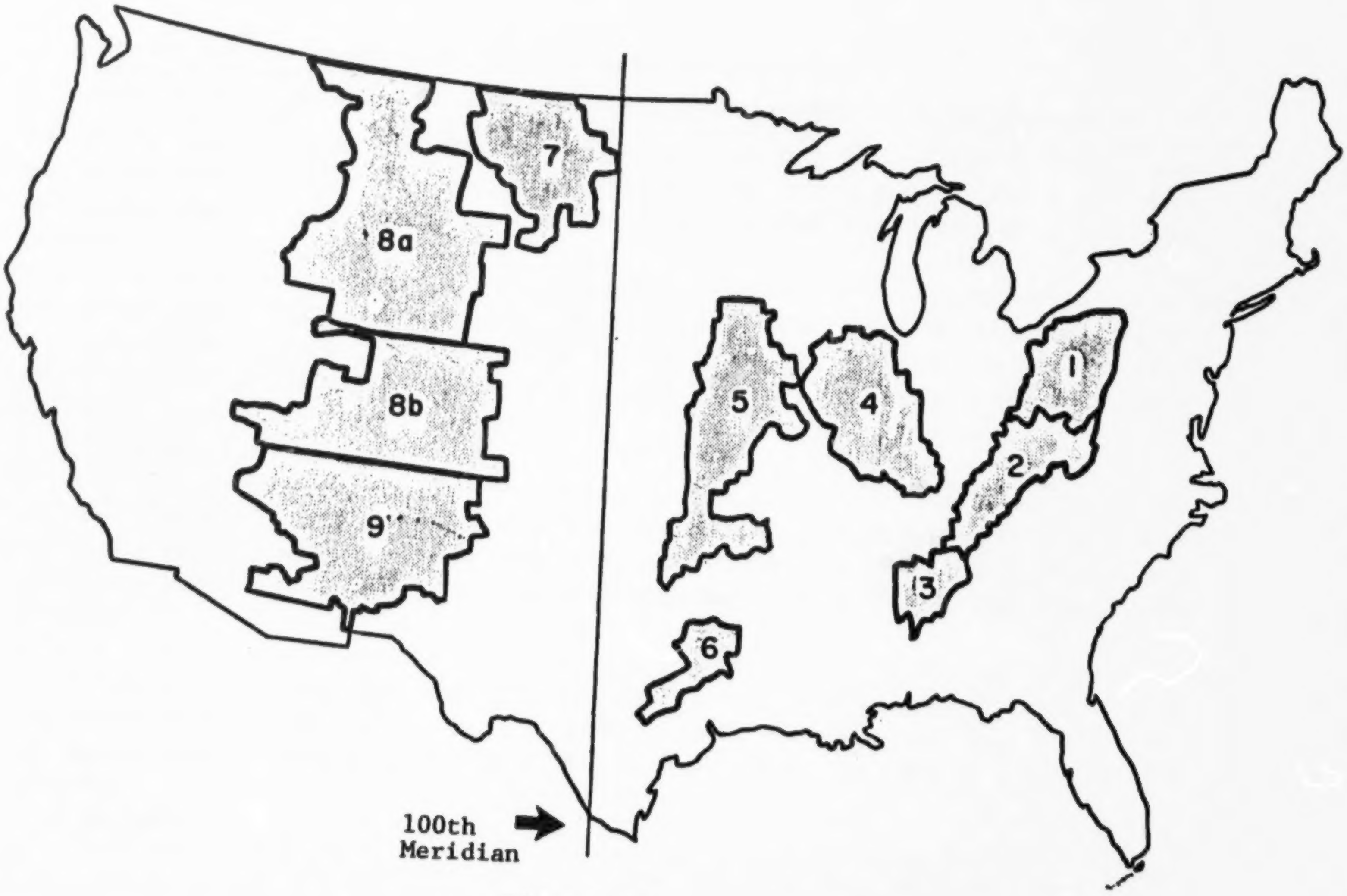

Figure V-3
COAL MINING REGIONS

Source: (10)

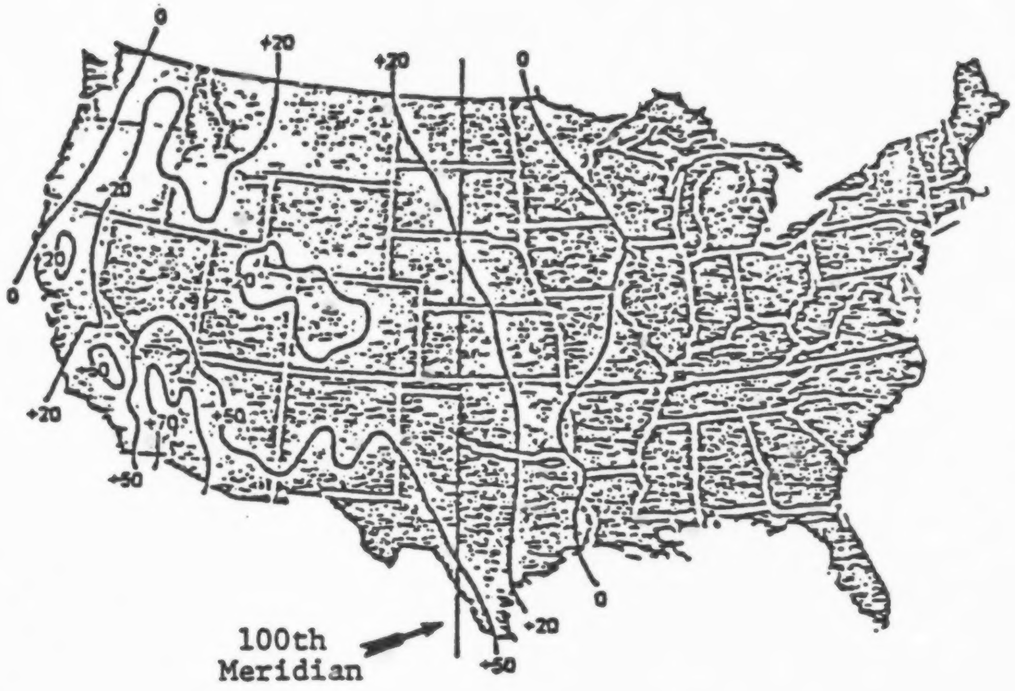

Figure V-4
RELATION OF AREAS OF POSITIVE EVAPOTRANSPIRATION
TO THE 100th MERIDIAN

Figure V-5

OBSERVED AND EXPECTED FREQUENCIES
OF TSS CONCENTRATIONS
AT WESTERN ALKALINE MINES

	QUADRANTS				
	1	2	3	4	
Influent	3 (3)	0 (2)	3 (3)	5 (3)	11
Effluent	4 (4)	5 (4)	3 (4)	3 (3)	15
	7	5	6	8	26

Expected frequencies are given in parentheses.

expected frequencies are found by taking 25 percent of the available samples. Since there were 11 influent samples, one would expect approximately three to fall into each quadrant if the distribution of TSS at Western mines was similar to that at Eastern mines. Figure V-5 shows that in most cases the observed frequencies are similar to the expected frequencies. The largest differences are found in the second and fourth quadrants of the influent distribution. Calculation of a chi square statistic indicates that these differences are not statistically significant. Based on these facts, a separate subcategory for western mines is not warranted.

SECTION VI

SELECTION OF POLLUTANT PARAMETERS

INTRODUCTION

The Agency has studied coal mining wastewaters to determine the presence or absence of toxic, conventional, and non-conventional pollutants. This section will address the selection of pollutant parameters for post mining discharges and effluents that have undergone BPT treatment. The quantities and treatability of pollutants in these treated wastewaters will form the basis for selection of pollutant parameters for regulation. The CWA requires that effluent limitations be established for toxic pollutants referred to in Section 307(a)(1). These pollutants, and the conventional and selected nonconventional pollutants are summarized in Table VI-1. The Settlement Agreement in Natural Resources Defense Council, Incorporated vs. Train, 8 ERC 2120 (D.D.C. 1976), modified, 12 ERC 1833 (D.D.C. 1979), provides for the exclusion of particular pollutants, categories and subcategories (Paragraph 8), according to the criteria summarized below:

1. Equal or more stringent protection is already provided by EPA's guidelines and standards under the Act.

2. The pollutant is present in the effluent discharge solely as a result of its presence in the intake water taken from the same body of water into which it is discharged.

3. The pollutant is not detectable in the effluent within the category by approved analytical methods or methods representing the state-of-the-art capabilities. (Note: this includes cases in which the pollutant is present solely as a result of contamination during sampling and analysis by sources other than the wastewater.)

4. The pollutant is detected in only a small number of sources within the category and is uniquely related to only those sources.

5. The pollutant is present only in trace amounts and is neither causing nor likely to cause toxic effects.

6. The pollutant is present in amounts too small to be effectively reduced by known technologies.

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Table VI-1

LIST OF 129 PRIORITY POLLUTANTS, CONVENTIONALS AND NON-CONVENTIONALS (1)

Priority Pollutants

1. *acenaphthene (B)
2. *acrolein (V)***
3. *acrylonitrile (V)
4. *benzene (V)
5. *benzidene (B)
6. *carbon tetrachloride (tetrachloromethane) (V)
7. chlorobenzene (V)
8. 1,2,4-trichlorobenzene (B)
9. hexachlorobenzene (B)
10. 1,2-dichloroethane (V)
11. 1,1,1-trichlorethane (V)
12. hexachlorethane (B)
13. 1,1-dichloroethane (V)
14. 1,1,2-trichloroethane (V)
15. 1,1,2,2-tetrachloroethane (V)
16. chloroethane (V)
17. bis (chloromethyl) ether (V)
18. bis (2-chloroethyl) ether (B)
19. 2-chloroethyl vinyl ether (mixed) (V)
20. 2-chloronaphthalene (B)
21. 2,4,6-trichlorophenol (A)***
22. parachlorometa cresol (A)
23. *chloroform (trichloromethane) (V)
24. *2-chlorophenol (A)
25. 1,2-dichlorobenzene (B)
26. 1,3-dichlorobenzene (B)
27. 1,4-dichlorobenzene (B)
28. 3,3'-dichlorobenzidine (B)
29. 1,1-dichloroethylene (V)
30. 1,2-trans-dischloroethylene (V)
31. *2,4-dichlorophenol (A)
32. 1,2-dichloropropane (V)
33. 1,2-dichloropropylene (1,3-dichloropropene) (V)
34. *2,4-dimenthylphenol (A)
35. 2,4-dinitrotoluene (B)
36. 2,6,-dinitrotoluene (B)
37. *1,2-diphenylhydrazine (B)
38. *ethylbenzene (V)
39. *fluoranthene (B)
40. 4-chlorophenyl phenyl ether (B)
41. 4-bromophnyl phenyl ether (B)
42. bis(2-chloroisopropyl) ether (B)

Table VI-1 (Continued)

LIST OF 129 PRIORITY POLLUTANTS, CONVENTIONALS AND NON-CONVENTIONALS (1)

43. bis(2-chloroethoxy) methane (B)
44. methylene chloride (dichloromethane) (V)
45. methyl chloride (chloromethane) (V)
46. methyl bromide (bromomethane) (V)
47. bromoform (tribromomethane) (V)
48. dichlorobromomethane (V)
49. trichlorofluoromethane (V)
50. dichlorodifluoromethane (V)
51. chlorodibromomethane (V)
52. *hexachlorobutadiene (B)
53. *hexachlorocyclopentadiene (B)
54. *isophorone (B)
55. *naphthalene (B)
56. *nitrobenzene (B)
57. 2-nitrophenol (A)
58. 4-nitrophenol (A)
59. *2,4-dinitrophenol (A)
60. 4,6-dinitro-o-cresol (A)
61. N-nitrosodimethylamine (B)
62. N-nitrosodiphenylamine (B)
63. N-nitrosodi-n-propylamine (B)
64. *pentachlorophenol (A)
65. *phenol (A)
66. bis(2-ethylhexyl) phthalate (B)
67. butyl benzyl phthalate (B)
68. di-n-butyl phthalate (B)
69. di-n-octyl phthalate (B)
70. diethyl phthalate (B)
71. dimethyl phthalate (B)
72. benzo (a)anthracene (1,2-benzanthracene) (B)
73. benzo (a)pyrene (3,4-benzopyrene) (B)
74. 3,4-benzofluoranthene (B)
75. benzo(k)fluoranthane (11,12-benzofluoranthene) (B)
76. chrysene (B)
77. acenaphthylene (B)
78. anthracene (B)
79. benzo(ghi)perylene (1,12-benzoperylene) (B)
80. fluorene (B)
81. phenathrene (B)
82. dibenzo (a,h)anthracene (1,2,5,6-dibenzanthracene) (B)
83. indeno (1,2,3-cd)(2,3,-o-phenylenepyrene) (B)
84. pyrene (B)
85. *tetrachloroethylene (V)
86. *toluene (V)

Table VI-1 (Continued)

LIST OF 129 PRIORITY POLLUTANTS, CONVENTIONALS AND NON-CONVENTIONALS (1)

87. *trichloroethylene (V)
88. *vinyl chloride (chloroethylene) (V)
89. *aldrin (P)
90. *dieldrin (P)
91. *chlordane (technical mixture and metabolites) (P)
92. 4,4'-DDT (P)
93. 4,4'-DDE(p,p'DDX) (P)
94. 4,4'-DDD(p,p'TDE) (P)
95. a-endosulfan-Alpha (P)
96. b-endosulfan-Beta (P)
97. endosulfan sulfate (P)
98. endrin (P)
99. endrin aldehyde (P)
100. heptachlor (P)
101. heptachlor epoxide (P)
102. a-AHC-alpha (P) (B)
103. b-BHC-beta (P) (V)
104. r-BHC (lindane)-gamma (P)
105. g-BHC-delta (P)
106. PCB-1242 (Arochlor 1242) (P)
107. PCB-1254 (Arochlor 1254) (P)
108. PCB-1221 (Arochlor 1221) (P)
109. PCB-1232 (Arochlor 1232) (P)
110. PCB-1248 (Arochlor 1248) (P)
111. PCB-1260 (Arochlor 1260) (P)
112. PCB-1016 (Arochlor 1016) (P)
113. *Toxaphene (P)
114: **2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) (P)
115. *Antimony (Total)
116. *Arsenic (Total)
117. *Asbestos (Fibrous)
118. *Beryllium (Total)
119. *Cadmium (Total)
120. *Chromium (Total)
121. *Copper (Total)
122. *Cyanide (Total)
123. *Lead (Total)
124. *Mercury (Total)
125. *Nickel (Total)
126. *Selenium (Total)
127. *Silver (Total)
128. *Thallium (Total)
129. *Zinc (Total)

Table VI-1 (Continued)

LIST OF 129 PRIORITY POLLUTANTS, CONVENTIONALS AND NON-CONVENTIONALS (1)

Conventionals

pH
Total Suspended Solids

Non-Conventionals

Iron
Manganese
Chemical Oxygen Demand (COD)
Total Organic Carbon (TOC)
Settleable Solids (SS)

---

*Specific compounds and chemical classes as listed in the consent degree.
**This compound was specifically listed in the consent degree.
***B = analyzed in the base-neutral extraction fraction
V = analyzed in the volatile organic fraction
A = analyzed in the acid extraction fraction
P = pesticide/polychlorinated diphenyl

7. The pollutant is effectively controlled by the technologies upon which other effluent limitations and guidelines are based. All pollutants detected in treated effluents of the coal mining industry are summarized in Table VI-2. These results are also summarized by subcategory in Tables VI-3 through VI-7.

POLLUTANTS SELECTED FOR REGULATION IN THE COAL MINING POINT SOURCE CATEGORY

Specific effluent limitations are being established for total suspended solids, pH, iron and manganese for each subcategory except post mining discharges from reclamation areas. (See the Coal Mining Development Document for the BPT Regulations, for an explanation of the selection of these pollutants and development of their limitations.) Settleable solids and pH have been selected to control effluents from reclamation areas and discharges from all subcategories during rainfall events.

PRIORITY ORGANICS EXCLUDED FROM REGULATION

All of the priority organic pollutants are excluded from regulation. The reasons for their exclusion are presented in Table VI-8 and are discussed below.

Priority Organics Not Detected in Treated Effluents

The Settlement Agreement provides for the exclusion from regulation of toxic pollutants not detectable by approved methods or methods representing state-of-the-art capabilities. The sixty-seven organic priority pollutants not detected during sampling and thus excluded from regulation are listed in Table VI-9.

Priority Organics Detected Due to Laboratory Analysis and Field Sampling Contamination

Ten of the priority organics were detected in one or more of the treated effluent samples; however, their presence is believed to be the sole result of contamination by sources in the field or laboratory independent of the composition of the actual wastewater. Table VI-10 tabulates the pollutants in this category. Field controls and blanks were used during each phase of the sampling program (Screening,

Table VI-2A

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	53	0	0	.	*	.	.	*	.
ACROLEIN	51	0	0	.	*	.	.	*	.
ACRYLONITRILE	51	0	0	.	*	.	.	*	.
BENZENE	51	21	2	0	0	2	4	7	16
BENZIDENE	53	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	51	0	0	.	*	.	.	*	.
CHLOROBENZENE	50	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	53	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	53	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	51	2	0	1	*	1	1	*	1
1,1,1-TRICHLOROETHANE	51	11	0	1	1	2	2	3	3
HEXACHLOROETHANE	53	1	0	3	*	3	3	*	3
1,1-DICHLOROETHANE	51	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	51	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	51	1	0	3	*	3	3	*	3
CHLOROETHANE	51	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	51	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	53	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	51	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	53	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	51	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	51	0	0	.	*	.	.	*	.
CHLOROFORM	51	40	22	1	3	13	60	128	476
2-CHLOROPHENOL	51	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	53	2	1	3	*	3	11	*	18
1,3-DICHLOROBENZENE	53	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	53	1	0	3	*	3	3	*	3
3,3-DICHLOROBENZIDINE	52	1	0	3	*	3	3	*	3

Table VI-2A (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	51	3	0	3	*	3	3	*	3
1,2-TRANS-DICHLOROETHYLENE	51	11	0	0	0	2	2	3	10
2,4-DICHLOROPHENOL	51	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	51	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	51	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	51	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	53	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	52	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	53	0	0	.	*	.	.	*	.
ETHYLBENZENE	52	8	1	1	*	3	3	*	11
FLUORANTHENE	53	1	0	3	*	3	3	*	3
4-CHLOROPHENYL PHENYL ETHER	53	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	53	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	53	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	53	1	0	3	*	3	3	*	3
METHYLENE CHLORIDE (DICHLOROMETHANE)	51	47	41	3	3	895	5743	9692	71000
METHYL CHLORIDE	51	0	0	.	*	.	.	*	.
METHYL BROMIDE	51	0	0	.	*	.	.	*	.
BROMOFORM	51	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	51	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	51	7	7	14	*	17	21	*	37
DICHLORODIFLUOROMETHANE	51	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	51	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	53	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	53	0	0	.	*	.	.	*	.
ISOPHORONE	53	0	0	.	*	.	.	*	.
NAPHTHALENE	53	4	3	3	*	11	10	*	14
NITROBENZENE	53	0	0	.	*	.	.	*	.

Table VI-2A (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	51	0	0	.	*	.	.	*	.
4-NITROPHENOL	51	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	51	1	0	3	*	3	3	*	3
4,6-DINITRO-O-CRESOL	51	1	0	3	*	3	3	*	3
N-NITROSODIMETHYLAMINE	53	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	53	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	53	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	51	1	0	3	*	3	3	*	3
PHENOL	51	8	0	3	*	3	3	*	3
BIS(2-ETHYLHEXYL) PHTHALATE	52	36	27	3	3	170	935	1846	11000
BUTYL BENZYL PHTHALATE	53	6	0	3	*	3	3	*	3
DI-N-BUTYL PHTHALATE	51	25	15	3	3	63	244	605	960
DI-N-OCTYL PHTHALATE	53	1	0	3	*	3	3	*	3
DIETHYL PHTHALATE	52	12	3	1	1	3	101	315	790
DIMETHYL PHTHALATE	53	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	51	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	53	2	0	3	*	3	5	*	6
BENZO(B)FLUORANTHENE	53	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	53	2	2	13	*	13	13	*	13
CHRYSENE	51	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	53	0	0	.	*	.	.	*	.
ANTHRACENE	51	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	53	4	2	3	*	3	8	*	13
FLUORENE	53	1	0	1	*	1	1	*	1
PHENANTHRENE	51	1	0	3	*	3	3	*	3
DIBENZO(A,H)ANTHRACENE	53	3	2	10	*	11	11	*	12
INDENO(1,2,3-C,D)PYRENE	53	3	3	10	*	10	11	*	11
PYRENE	53	1	0	2	*	2	2	*	2

Table VI-2A(Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	51	17	8	1	1	4	12	23	81
TOLUENE	51	22	5	0	0	2	7	20	40
TRICHLOROETHYLENE	51	3	0	1	*	2	2	*	3
VINYL CHLORIDE	51	0	0	.	*	.	.	*	.
ALDRIN	47	2	0	2.24	*	2.24	2.24	*	2.24
DIELDRIN	47	0	0	.	*	.	.	*	.
CHLORDANE	49	0	0	.	*	.	.	*	.
4,4-DDT	47	1	0	2.24	*	2.24	2.24	*	2.24
4,4-DDE	47	0	0	.	*	.	.	*	.
4,4-DDD	47	1	0	2.24	*	2.24	2.24	*	2.24
ENDOSULFAN-ALPHA	47	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	47	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	49	0	0	.	*	.	.	*	.
ENDRIN	49	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	47	0	0	.	*	.	.	*	.
HEPTACHLOR	47	2	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR EPOXIDE	47	1	0	2.24	*	2.24	2.24	*	2.24
BHC-ALPHA	47	3	0	0.10	*	1.17	1.52	*	2.24
BHC-BETA	47	3	0	0.26	*	1.25	1.58	*	2.24
BHC (LINDANE)-GAMMA	47	2	0	2.24	*	2.24	2.24	*	2.24
BHC-DELTA	47	3	0	0.10	*	1.17	1.52	*	2.24
PCB-1242 (AROCHLOR 1242)	49	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	49	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	49	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	49	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	49	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	49	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	49	0	0	.	*	.	.	*	.

Table VI-2A (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	49	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	53	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	48	6	2	3	*	3	13	*	35
BENZO(A)ANTHRACENE/CHRYSENE	14	1	0	3	*	3	3	*	3
BENZO(3,4/K)FLUORANTHENE	12	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	114	44	17	1	1	4	29	92	255
ARSENIC (TOTAL)	114	44	14	2	2	6	12	29	72
BERYLLIUM (TOTAL)	114	7	0	0	*	1	2	*	3
CADMIUM (TOTAL)	114	16	9	3	4	12	12	17	23
CHROMIUM (TOTAL)	114	63	55	6	*	30	46	63	860
COPPER (TOTAL)	114	61	33	3	6	11	15	27	46
CYANIDE (TOTAL)	62	5	0	3	*	4	5	*	7
LEAD (TOTAL)	114	22	13	2	3	21	66	104	620
MERCURY (TOTAL)	114	39	1	0.10	0.30	0.70	1.47	2.51	13.00
NICKEL (TOTAL)	112	25	23	5	15	60	75	138	182
SELENIUM (TOTAL)	114	32	15	1	1	6	22	64	160
SILVER (TOTAL)	114	29	21	2	5	15	16	26	31
THALLIUM (TOTAL)	113	19	5	1	1	2	13	24	137
ZINC (TOTAL)	113	85	79	6	10	40	59	131	382

Table VI-2B

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
ALL SUBCATEGORIES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	110	109	32	2500	15925	28507	62200	450000
PH (UNITS)	113	113	3.2	6.6	7.8	7.6	8.4	10.8
IRON (TOTAL)	115	111	21	128	528	1239	3120	11205
MANGANESE (TOTAL)	110	98	11	25	303	922	2020	7167
ASBESTOS(TOTAL-FIBERS/LITER)	24	24	560000	1379E4	8800E5	6766E6	1800E7	5200E7
COD	62	55	40	11600	24350	89569	48000	3260E3
DISSOLVED SOLIDS	45	45	35000	115000	805000	1232E3	2850E3	6800E3
TOTAL VOLATILE SOLIDS	46	46	26000	51200	135000	1689E3	467599	6700E4
VOLATILE SUSPENDED SOLIDS	35	27	1000	1000	4700	13304	15120	200000
SETTLEABLE SOLIDS	66	47	0.0	0.0	0.0	4.9	0.2	200.0
TOTAL ORGANIC CARBON	56	51	260	1051	9000	15366	38940	65000
FREE ACIDITY (CACO3)	2	2	50	*	50	14025	*	28000
MO ALKALINITY (CACO3)	47	47	100	16400	130000	170428	383000	620000
PHENOLICS(4AAP)	61	10	2	2	13	15	20	40
SULFATE	6	6	130000	*	246667	552778	*	1373E3
TOTAL ACIDITY (CACO3)	4	4	3000	*	4000	5500	*	10500
TOTAL SOLIDS	43	43	7000	263000	835000	5895E3	4043E3	1900E5

Table VI-3

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	13	0	0	.	*	.	.	*	.
ACROLEIN	13	0	0	.	*	.	.	*	.
ACRYLONITRILE	13	0	0	.	*	.	.	*	.
BENZENE	13	8	0	1	*	2	3	*	7
BENZIDENE	13	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	13	0	0	.	*	.	.	*	.
CHLOROBENZENE	13	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	13	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	13	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	13	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	13	3	0	1	*	1	2	*	2
HEXACHLOROETHANE	13	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	13	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	13	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	13	0	0	.	*	.	.	*	.
CHLOROETHANE	13	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	13	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	13	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	13	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	13	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	11	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	11	0	0	.	*	.	.	*	.
CHLOROFORM	13	10	6	1	1	14	72	170	442
2-CHLOROPHENOL	11	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	13	0	0	.	*	.	.	*	.
1,3-DICHLOROBENZENE	13	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	13	0	0	.	*	.	.	*	.
3,3-DICHLOROBENZIDINE	12	0	0	.	*	.	.	*	.

Table VI-3 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	13	0	0	.	*	.	.	*	.
1,2-TRANS-DICHLOROETHYLENE	13	4	0	1	*	1	2	*	2
2,4-DICHLOROPHENOL	11	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	13	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	13	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	11	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	13	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	13	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	13	0	0	.	*	.	.	*	.
ETHYLBENZENE	14	3	0	1	*	1	2	*	3
FLUORANTHENE	13	0	0	.	*	.	.	*	.
4-CHLOROPHENYL PHENYL ETHER	13	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	13	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	13	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	13	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	13	13	12	7	7	2250	3988	9843	13000
METHYL CHLORIDE	13	0	0	.	*	.	.	*	.
METHYL BROMIDE	13	0	0	.	*	.	.	*	.
BROMOFORM	13	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	13	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	13	2	2	14	*	14	26	*	37
DICHLORODIFLUOROMETHANE	13	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	13	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	13	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	13	0	0	.	*	.	.	*	.
ISOPHORONE	13	0	0	.	*	.	.	*	.
NAPHTHALENE	13	2	2	12	*	12	13	*	14
NITROBENZENE	13	0	0	.	*	.	.	*	.

Table VI-3 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	11	0	0	.	*	.	.	*	.
4-NITROPHENOL	11	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	11	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	11	0	0	.	*	.	.	*	.
N-NITROSODIMETHYLAMINE	13	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	13	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	13	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	11	0	0	.	*	.	.	*	.
PHENOL	11	0	0	.	*	.	.	*	.
BIS(2-ETHYLHEXYL) PHTHALATE	13	11	11	4	4	495	1586	3004	11000
BUTYL BENZYL PHTHALATE	13	1	0	3	*	3	3	*	3
DI-N-BUTYL PHTHALATE	12	8	7	3	*	219	281	*	600
DI-N-OCTYL PHTHALATE	13	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	13	4	1	1	*	1	4	*	13
DIMETHYL PHTHALATE	13	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	11	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	13	2	0	3	*	3	5	*	6
BENZO(B)FLUORANTHENE	13	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	13	2	2	13	*	13	13	*	13
CHRYSENE	11	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	13	0	0	.	*	.	.	*	.
ANTHRACENE	11	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	13	2	2	11	*	11	12	*	13
FLUORENE	13	0	0	.	*	.	.	*	.
PHENANTHRENE	11	1	0	3	*	3	3	*	3
DIBENZO(A,H)ANTHRACENE	13	2	1	10	*	10	11	*	12
INDENO(1,2,3-C,D)PYRENE	13	2	2	11	*	11	11	*	11
PYRENE	13	0	0	.	*	.	.	*	.

Table VI-3 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXICE POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	13	5	3	2	*	9	13	*	31
TOLUENE	13	7	0	0	*	2	3	*	5
TRICHLOROETHYLENE	13	0	0	.	*	.	.	*	.
VINYL CHLORIDE	13	0	0	.	*	.	.	*	.
ALDRIN	9	0	0	.	*	.	.	*	.
DIELDRIN	9	0	0	.	*	.	.	*	.
CHLORDANE	9	0	0	.	*	.	.	*	.
4,4-DDT	9	0	0	.	*	.	.	*	.
4,4-DDE	9	0	0	.	*	.	.	*	.
4,4-DDD	9	0	0	.	*	.	.	*	.
ENDOSULFAN-ALPHA	9	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	9	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	9	0	0	.	*	.	.	*	.
ENDRIN	9	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	9	0	0	.	*	.	.	*	.
HEPTACHLOR	9	0	0	.	*	.	.	*	.
HEPTACHLOR EPOXIDE	9	0	0	.	*	.	.	*	.
BHC-ALPHA	9	1	0	2.24	*	2.24	2.24	*	2.24
BHC-BETA	9	1	0	2.24	*	2.24	2.24	*	2.24
BHC (LINDANE)-GAMMA	9	1	0	2.24	*	2.24	2.24	*	2.24
BHC-DELTA	9	1	0	2.24	*	2.24	2.24	*	2.24
PCB-1242 (AROCHLOR 1242)	9	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	9	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	9	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	9	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	9	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	9	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	9	0	0	.	*	.	.	*	.

Table VI-3 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	9	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	13	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	11	2	2	28	*	28	32	*	35
BENZO(A)ANTHRACENE/CHRYSENE	4	0	0	.	*	.	.	*	.
BENZO(3,4/K)FLUORANTHENE	2	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	23	10	1	2	2	3	5	9	13
ARSENIC (TOTAL)	23	10	7	2	2	13	16	28	37
BERYLLIUM (TOTAL)	23	1	0	3	*	3	3	*	3
CADMIUM (TOTAL)	23	2	2	12	*	12	15	*	18
CHROMIUM (TOTAL)	23	13	12	9	10	27	39	67	128
COPPER (TOTAL)	23	15	9	6	6	12	14	21	27
CYANIDE (TOTAL)	15	1	0	6	*	6	6	*	6
LEAD (TOTAL)	23	5	3	3	*	40	167	*	620
MERCURY (TOTAL)	23	10	0	0.30	0.30	0.90	1.09	1.60	2.50
NICKEL (TOTAL)	23	8	7	5	*	69	82	*	180
SELENIUM (TOTAL)	23	11	7	1	1	12	25	65	77
SILVER (TOTAL)	23	11	9	2	2	11	16	26	30
THALLIUM (TOTAL)	23	3	0	2	*	2	2	*	3
ZINC (TOTAL)	23	19	18	6	16	38	63	142	187

Table VI-3 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	22	21	2700	3865	14000	34194	62300	197850
PH (UNITS)	24	24	3.5	6.1	7.3	7.5	8.6	10.8
IRON (TOTAL)	23	22	63	71	859	1575	4400	6500
MANGANESE (TOTAL)	23	22	22	82	1300	2086	5672	7167
ASBESTOS(TOTAL-FIBERS/LITER)	8	8	560000	*	1300E5	5456E5	*	2100E8
COD	15	10	10200	10200	23667	43637	49400	190000
DISSOLVED SOLIDS	14	14	35000	41400	330000	1223E3	2620E3	6600E3
TOTAL VOLATILE SOLIDS	10	10	30000	30000	135000	218625	430000	530000
VOLATILE SUSPENDED SOLIDS	6	4	1400	*	1400	3500	*	6600
SETTLEABLE SOLIDS	14	9	0.0	*	0.0	0.1	*	0.1
TOTAL ORGANIC CARBON	15	14	260	365	6900	7457	15640	17200
FREE ACIDITY (CACO3)	1	1	28000	*	28000	28000	*	28000
NO ALKALINITY (CACO3)	13	13	100	3670	29000	47238	113400	130000
PHENOLICS(4AAP)	15	2	14	*	14	17	*	20
SULFATE	5	5	130000	*	441667	629333	*	1373E3
TOTAL SOLIDS	10	10	430000	430000	2900E3	3090E3	5000E3	8100E3

Table VI-4

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	30	0	0	.	*	.	.	*	.
ACROLEIN	28	0	0	.	*	.	.	*	.
ACRYLONITRILE	28	0	0	.	*	.	.	*	.
BENZENE	28	9	1	0	*	1	3	*	18
BENZIDENE	30	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	28	0	0	.	*	.	.	*	.
CHLOROBENZENE	27	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	30	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	30	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	28	2	0	1	*	1	1	*	1
1,1,1-TRICHLOROETHANE	28	4	0	1	*	1	2	*	3
HEXACHLOROETHANE	30	1	0	3	*	3	3	*	3
1,1-DICHLOROETHANE	28	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	28	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	28	0	0	.	*	.	.	*	.
CHLOROETHANE	28	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	28	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	30	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	28	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	30	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	30	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	30	0	0	.	*	.	.	*	.
CHLOROFORM	28	21	11	2	3	11	80	121	488
2-CHLOROPHENOL	30	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	30	2	1	3	*	3	11	*	18
1,3-DICHLOROBENZENE	30	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	30	1	0	3	*	3	3	*	3
3,3-DICHLOROBENZIDINE	30	1	0	3	*	3	3	*	3

Table VI-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	28	2	0	3	*	3	3	*	3
1,2-TRANS-DICHLOROETHYLENE	28	3	0	0	*	1	1	*	2
2,4-DICHLOROPHENOL	30	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	28	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	28	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	30	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	30	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	30	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	30	0	0	.	*	.	.	*	.
ETHYLBENZENE	28	0	0	.	*	.	.	*	.
FLUORANTHENE	30	4	1	1	*	3	5	*	11
4-CHLOROPHENYL PHENYL ETHER	30	1	0	3	*	3	3	*	3
4-BROMOPHENYL PHENYL ETHER	30	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	30	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	30	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	28	0	0	.	*	.	.	*	.
METHYL CHLORIDE	28	25	22	3	3	782	5090	8482	71000
METHYL BROMIDE	28	0	0	.	*	.	.	*	.
BROMOFORM	28	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	28	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	28	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	28	4	4	18	*	17	19	*	25
CHLORODIBROMOMETHANE	28	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	30	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	30	0	0	.	*	.	.	*	.
ISOPHORONE	30	0	0	.	*	.	.	*	.
NAPHTHALENE	30	1	1	11	*	11	11	*	11
NITROBENZENE	30	0	0	.	*	.	.	*	.

Table VI-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	30	0	0	.	*	.	.	*	.
4-NITROPHENOL	30	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	30	1	0	3	*	3	3	*	3
4,6-DINITRO-O-CRESOL	30	1	0	3	*	3	3	*	3
N-NITROSODIMETHYLAMINE	30	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	30	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	30	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	30	1	0	3	*	3	3	*	3
PHENOL	30	5	0	3	*	3	3	*	3
BIS(2-ETHYLHEXYL) PHTHALATE	30	16	12	3	3	170	572	778	4400
BUTYL BENZYL PHTHALATE	30	5	0	3	*	3	3	*	3
DI-N-BUTYL PHTHALATE	30	12	6	3	3	3	280	674	980
DI-N-OCTYL PHTHALATE	30	1	0	3	*	3	3	*	3
DIETHYL PHTHALATE	30	5	1	3	*	3	81	*	390
DIMETHYL PHTHALATE	30	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	30	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	30	0	0	.	*	.	.	*	.
BENZO(B)FLUORANTHENE	30	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	30	0	0	.	*	.	.	*	.
CHRYSENE	30	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	30	0	0	.	*	.	.	*	.
ANTHRACENE	30	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	30	2	0	3	*	3	3	*	3
FLUORENE	30	1	0	1	*	1	1	*	1
PHENANTHRENE	30	0	0	.	*	.	.	*	.
DIBENZO(A,H)ANTHRACENE	30	1	1	12	*	12	12	*	12
INDENO(1,2,3-C,D)PYRENE	30	1	1	10	*	10	10	*	10
PYRENE	30	1	0	2	*	2	2	*	2

Table VI-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	28	8	2	1	*	4	14	*	81
TOLUENE	28	10	4	0	0	2	12	40	40
TRICHLOROETHYLENE	28	2	0	1	*	1	2	*	3
VINYL CHLORIDE	28	0	0	.	*	.	.	*	.
ALDRIN	28	1	0	2.24	*	2.24	2.24	*	2.24
DIELDRIN	28	0	0	.	*	.	.	*	.
CHLORDANE	30	0	0	.	*	.	.	*	.
4,4-DDT	28	0	0	.	*	.	.	*	.
4,4-DDE	28	0	0	.	*	.	.	*	.
4,4-DDD	28	0	0	.	*	.	.	*	.
ENDOSULFAN-ALPHA	28	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	28	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	30	0	0	.	*	.	.	*	.
ENDRIN	30	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	28	0	0	.	*	.	.	*	.
HEPTACHLOR	28	1	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR EPOXIDE	28	1	0	2.24	*	2.24	2.24	*	2.24
BHC-ALPHA	28	1	0	0.10	*	0.10	0.10	*	0.10
BHC-BETA	28	1	0	0.28	*	0.28	0.28	*	0.28
BHC (LINDANE)-GAMMA	28	1	0	2.24	*	2.24	2.24	*	2.24
BHC-DELTA	28	1	0	0.10	*	0.10	0.10	*	0.10
PCB-1242 (AROCHLOR 1242)	30	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	30	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	30	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	30	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	30	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	30	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	30	0	0	.	*	.	.	*	.

Table VI-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	30	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	30	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	29	3	0	3	*	3	3	*	3
BENZO(A)ANTHRACENE/CHRYSENE	8	1	0	3	*	3	3	*	3
BENZO(3,4/K)FLUORANTHENE	8	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	57	18	5	1	1	3	6	15	18
ARSENIC (TOTAL)	57	25	4	2	2	6	9	12	72
BERYLLIUM (TOTAL)	57	1	0	0	*	0	0	*	0
CADMIUM (TOTAL)	57	7	5	5	*	14	14	*	23
CHROMIUM (TOTAL)	57	32	28	8	10	34	63	64	860
COPPER (TOTAL)	57	24	9	3	5	9	13	27	40
CYANIDE (TOTAL)	37	4	0	3	*	3	4	*	7
LEAD (TOTAL)	57	14	8	2	2	20	36	81	109
MERCURY (TOTAL)	57	25	1	0.10	0.30	0.65	1.63	2.20	13.00
NICKEL (TOTAL)	57	9	8	10	*	55	62	*	146
SELENIUM (TOTAL)	57	12	3	1	1	3	19	24	180
SILVER (TOTAL)	57	9	9	13	*	17	19	*	25
THALLIUM (TOTAL)	56	9	2	1	*	2	5	*	23
ZINC (TOTAL)	56	37	33	7	10	43	62	101	168

Table VI-4 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ACID DRAINAGE MINES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	58	58	32	2000	12500	29542	70627	450000
PH (UNITS)	58	56	3.2	7.1	7.8	7.7	8.4	9.4
IRON (TOTAL)	57	54	21	132	390	892	2589	5100
MANGANESE (TOTAL)	58	47	11	18	170	381	1100	2800
ASBESTOS(TOTAL-FIBERS/LITER)	15	15	3300E4	3300E4	2050E6	1053E7	2950E7	5200E7
COD	37	35	40	9700	22413	117475	45500	3260E3
DISSOLVED SOLIDS	23	23	66000	205000	860000	1198E3	2780E3	3600E3
TOTAL VOLATILE SOLIDS	29	29	44000	65200	135000	2571E3	608426	6700E4
VOLATILE SUSPENDED SOLIDS	24	18	1000	1000	4000	16133	12880	200000
SETTLEABLE SOLIDS	32	26	0.0	0.0	0.0	8.2	0.4	200.0
TOTAL ORGANIC CARBON	34	31	1000	3067	9383	19595	47620	65000
FREE ACIDITY (CACO3)	1	1	50	*	50	50	*	50
MO ALKALINITY (CACO3)	23	23	23000	64900	245000	260783	494000	620000
PHENOLICS(4AAP)	36	5	2	*	9	16	*	40
TOTAL ACIDITY (CACO3)	1	1	10500	*	10500	10500	*	10500
TOTAL SOLIDS	27	27	148000	312000	820000	8031E3	2480E3	1900E5

Table VI-5

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	7	0	0	.	*	.	.	*	.
ACROLEIN	7	0	0	.	*	.	.	*	.
ACRYLONITRILE	7	0	0	.	*	.	.	*	.
BENZENE	7	2	1	1	*	1	7	*	12
BENZIDENE	7	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	7	0	0	.	*	.	.	*	.
CHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	7	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	7	3	0	2	*	2	2	*	3
HEXACHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	7	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	7	1	0	3	*	3	3	*	3
CHLOROETHANE	7	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	7	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	7	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	7	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	7	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	7	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	7	0	0	.	*	.	.	*	.
CHLOROFORM	7	6	3	3	*	3	21	*	78
2-CHLOROPHENOL	7	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,3-DICHLOROBENZENE	7	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	7	0	0	.	*	.	.	*	.
3,3-DICHLOROBENZIDINE	7	0	0	.	*	.	.	*	.

Table VI-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	7	1	0	3	*	3	3	*	3
1,2-TRANS-DICHLOROETHYLENE	7	3	0	1	*	2	5	*	10
2,4-DICHLOROPHENOL	7	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	7	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	7	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	7	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	7	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	6	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	7	0	0	.	*	.	.	*	.
ETHYLBENZENE	7	1	0	3	*	3	3	*	3
FLUORANTHENE	7	0	0	.	*	.	.	*	.
4-CHLOROPHENYL PHENYL ETHER	7	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	7	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	7	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	7	1	0	3	*	3	3	*	3
METHYLENE CHLORIDE (DICHLOROMETHANE)	7	6	4	3	*	463	3998	*	20000
METHYL CHLORIDE	7	0	0	.	*	.	.	*	.
METHYL BROMIDE	7	0	0	.	*	.	.	*	.
BROMOFORM	7	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	7	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	7	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	7	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	7	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	7	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	7	0	0	.	*	.	.	*	.
ISOPHORONE	7	0	0	.	*	.	.	*	.
NAPHTHALENE	7	1	0	3	*	3	3	*	3
NITROBENZENE	7	0	0	.	*	.	.	*	.

Table VI-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	7	0	0	.	*	.	.	*	.
4-NITROPHENOL	7	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	7	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	7	0	0	.	*	.	.	*	.
N-NITROSODIMETHYLAMINE	7	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	7	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	7	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	7	0	0	.	*	.	.	*	.
PHENOL	7	0	0	.	*	.	.	*	.
BIS(2-ETHYLHEXYL) PHTHALATE	7	3	0	3	*	3	3	*	3
BUTYL BENZYL PHTHALATE	6	6	3	3	*	3	160	*	510
DI-N-BUTYL PHTHALATE	7	0	0	.	*	.	.	*	.
DI-N-OCTYL PHTHALATE	6	3	1	3	*	3	92	*	270
DIETHYL PHTHALATE	7	0	0	.	*	.	.	*	.
DIMETHYL PHTHALATE	6	3	1	3	*	3	285	*	780
BENZO(A)ANTHRACENE	7	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	7	0	0	.	*	.	.	*	.
BENZO(B)FLUORANTHENE	7	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	7	0	0	.	*	.	.	*	.
CHRYSENE	7	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	7	0	0	.	*	.	.	*	.
ANTHRACENE	7	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	7	0	0	.	*	.	.	*	.
FLUORENE	7	0	0	.	*	.	.	*	.
PHENANTHRENE	7	0	0	.	*	.	.	*	.
DIBENZO(A,H)ANTHRACENE	7	0	0	.	*	.	.	*	.
INDENO(1,2,3-C,D)PYRENE	7	0	0	.	*	.	.	*	.
PYRENE	7	0	0	.	*	.	.	*	.

Table VI-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	7	3	1	3	*	4	9	*	20
TOLUENE	7	3	1	0	*	3	4	*	7
TRICHLOROETHYLENE	7	1	0	3	*	3	3	*	3
VINYL CHLORIDE	7	0	0	.	*	.	.	*	.
ALDRIN	7	0	0	.	*	.	.	*	.
DIELDRIN	7	0	0	.	*	.	.	*	.
CHLORDANE	7	0	0	.	*	.	.	*	.
4,4-DDT	7	0	0	.	*	.	.	*	.
4,4-DDE	7	0	0	.	*	.	.	*	.
4,4-DDD	7	0	0	.	*	.	.	*	.
ENDOSULFAN-ALPHA	7	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	7	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	7	0	0	.	*	.	.	*	.
ENDRIN	7	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	7	0	0	.	*	.	.	*	.
HEPTACHLOR	7	0	0	.	*	.	.	*	.
HEPTACHLOR EPOXIDE	7	0	0	.	*	.	.	*	.
BHC-ALPHA	7	0	0	.	*	.	.	*	.
BHC-BETA	7	0	0	.	*	.	.	*	.
BHC (LINDANE)-GAMMA	7	0	0	.	*	.	.	*	.
BHC-DELTA	7	0	0	.	*	.	.	*	.
PCB-1242 (AROCHLOR 1242)	7	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	7	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	7	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	7	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	7	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	7	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	7	0	0	.	*	.	.	*	.

Table VI-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY PREP PLANTS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	7	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	7	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	3	1	0	3	*	3	3	*	3
BENZO(A)ANTHRACENE/CHRYSENE	1	0	0	.	*	.	.	*	.
BENZO(3,4/K)FLUORANTHENE	1	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	9	3	0	1	*	1	2	*	3
ARSENIC (TOTAL)	9	4	1	2	*	3	10	*	30
BERYLLIUM (TOTAL)	9	0	0	.	*	.	.	*	.
CADMIUM (TOTAL)	9	1	0	3	*	3	3	*	3
CHROMIUM (TOTAL)	9	4	4	24	*	24	31	*	41
COPPER (TOTAL)	9	6	4	5	*	13	20	*	46
CYANIDE (TOTAL)	7	0	0	.	*	.	.	*	.
LEAD (TOTAL)	9	2	2	57	*	57	62	*	67
MERCURY (TOTAL)	9	1	0	0.30	*	0.30	0.30	*	0.30
NICKEL (TOTAL)	9	2	2	20	*	20	35	*	50
SELENIUM (TOTAL)	9	4	3	5	*	7	20	*	50
SILVER (TOTAL)	9	2	1	6	*	6	15	*	24
THALLIUM (TOTAL)	9	4	0	1	*	2	3	*	7
ZINC (TOTAL)	9	6	6	39	*	40	70	*	200

Table VI-5 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY PREP PLANTS
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	8	8	2500	*	11800	14044	*	29500
PH (UNITS)	9	9	6.2	*	7.1	7.4	*	9.1
IRON (TOTAL)	9	9	98	*	388	868	*	4400
MANGANESE (TOTAL)	6	5	25	*	68	247	*	700
ASBESTOS(TOTAL-FIBERS/LITER)	1	1	1400E5	*	1400E5	1400E5	*	1400E5
COD	7	7	20350	*	35200	44984	*	113000
DISSOLVED SOLIDS	2	2	560000	*	560000	1020E3	*	1480E3
TOTAL VOLATILE SOLIDS	4	4	94000	*	140000	210438	*	420000
VOLATILE SUSPENDED SOLIDS	3	3	3600	*	4200	10133	*	22000
SETTLEABLE SOLIDS	2	2	0.0	*	0.0	0.1	*	0.1
TOTAL ORGANIC CARBON	4	4	5875	*	11600	14869	*	25000
MO ALKALINITY (CACO3)	5	5	19000	*	40750	61900	*	116500
PHENOLICS(4AAP)	7	3	10	*	10	12	*	15
TOTAL ACIDITY (CACO3)	3	3	3000	*	3500	3833	*	4500
TOTAL SOLIDS	4	4	7000	*	530000	1334E3	*	3700E3

Table VI-6

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	3	0	0	.	*	.	.	*	.
ACROLEIN	3	0	0	.	*	.	.	*	.
ACRYLONITRILE	3	0	0	.	*	.	.	*	.
BENZENE	3	1	0	6	*	6	6	*	6
BENZIDENE	3	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	3	0	0	.	*	.	.	*	.
CHLOROBENZENE	3	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	3	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	3	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	3	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	3	1	0	2	*	2	2	*	2
HEXACHLOROETHANE	3	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	3	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	3	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	3	0	0	.	*	.	.	*	.
CHLOROETHANE	3	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	3	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	3	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	3	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	3	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	3	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	3	0	0	.	*	.	.	*	.
CHLOROFORM	3	3	2	3	*	11	166	*	476
2-CHLOROPHENOL	3	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	3	0	0	.	*	.	.	*	.
1,3-DICHLOROBENZENE	3	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	3	0	0	.	*	.	.	*	.
3,3-DICHLOROBENZIDINE	3	0	0	.	*	.	.	*	.

Table VI-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	3	0	0	.	*	.	.	*	.
1,2-TRANS-DICHLOROETHYLENE	3	1	0	2	*	2	2	*	2
2,4-DICHLOROPHENOL	3	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	3	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	3	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	3	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	3	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	3	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	3	0	0	.	*	.	.	*	.
ETHYLBENZENE	3	0	0	.	*	.	.	*	.
FLUORANTHENE	3	0	0	.	*	.	.	*	.
4-CHLOROPHENYL PHENYL ETHER	3	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	3	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	3	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	3	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	3	3	3	7	*	553	22369	*	66000
METHYL CHLORIDE	3	0	0	.	*	.	.	*	.
METHYL BROMIDE	3	0	0	.	*	.	.	*	.
BROMOFORM	3	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	3	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	3	1	1	22	*	22	22	*	22
DICHLORODIFLUOROMETHANE	3	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	3	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	3	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	3	0	0	.	*	.	.	*	.
ISOPHORONE	3	0	0	.	*	.	.	*	.
NAPHTHALENE	3	0	0	.	*	.	.	*	.
NITROBENZENE	3	0	0	.	*	.	.	*	.

Table VI-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	3	0	0	.	*	.	.	*	.
4-NITROPHENOL	3	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	3	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	3	0	0	.	*	.	.	*	.
N-NITROSODIMETHYLAMINE	3	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	3	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	3	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	3	0	0	.	*	.	.	*	.
PHENOL	3	0	0	.	*	.	.	*	.
BIS(2-ETHYLHEXYL) PHTHALATE	3	3	1	3	*	7	2038	*	6100
BUTYL BENZYL PHTHALATE	3	0	0	.	*	.	.	*	.
DI-N-BUTYL PHTHALATE	3	2	1	3	*	3	107	*	210
DI-N-OCTYL PHTHALATE	3	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	3	0	0	.	*	.	.	*	.
DIMETHYL PHTHALATE	3	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	3	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	3	0	0	.	*	.	.	*	.
BENZO(B)FLUORANTHENE	3	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	3	0	0	.	*	.	.	*	.
CHRYSENE	3	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	3	0	0	.	*	.	.	*	.
ANTHRACENE	3	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	3	0	0	.	*	.	.	*	.
FLUORENE	3	0	0	.	*	.	.	*	.
PHENANTHRENE	3	0	0	.	*	.	.	*	.
DIBENZO(A,H)ANTHRACENE	3	0	0	.	*	.	.	*	.
INDENO(1,2,3-C,D)PYRENE	3	0	0	.	*	.	.	*	.
PYRENE	3	0	0	.	*	.	.	*	.

Table VI-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	3	1	0	1	*	1	1	*	1
TOLUENE	3	2	0	2	*	2	3	*	3
TRICHLOROETHYLENE	3	0	0	.	*	.	.	*	.
VINYL CHLORIDE	3	0	0	.	*	.	.	*	.
ALDRIN	3	1	0	2.24	*	2.24	2.24	*	2.24
DIELDRIN	3	0	0	.	*	.	.	*	.
CHLORDANE	3	0	0	.	*	.	.	*	.
4,4-DDT	3	1	0	2.24	*	2.24	2.24	*	2.24
4,4-DDE	3	0	0	.	*	.	.	*	.
4,4-DDD	3	1	0	2.24	*	2.24	2.24	*	2.24
ENDOSULFAN-ALPHA	3	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	3	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	3	0	0	.	*	.	.	*	.
ENDRIN	3	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	3	0	0	.	*	.	.	*	.
HEPTACHLOR	3	1	0	2.24	*	2.24	2.24	*	2.24
HEPTACHLOR EPOXIDE	3	0	0	.	*	.	.	*	.
BHC-ALPHA	3	1	0	2.24	*	2.24	2.24	*	2.24
BHC-BETA	3	1	0	2.24	*	2.24	2.24	*	2.24
BHC (LINDANE)-GAMMA	3	0	0	.	*	.	.	*	.
BHC-DELTA	3	1	0	2.24	*	2.24	2.24	*	2.24
PCB-1242 (AROCHLOR 1242)	3	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	3	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	3	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	3	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	3	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	3	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	3	0	0	.	*	.	.	*	.

Table VI-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ASSOCIATED AREAS
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	3	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	3	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	3	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE/CHRYSENE	1	0	0	.	*	.	.	*	.
BENZO(3,4/K)FLUORANTHENE	1	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	8	2	0	2	*	2	3	*	4
ARSENIC (TOTAL)	8	3	0	2	*	3	3	*	4
BERYLLIUM (TOTAL)	8	0	0	.	*	.	.	*	.
CADMIUM (TOTAL)	8	2	2	15	*	15	16	*	17
CHROMIUM (TOTAL)	8	5	5	14	*	27	30	*	49
COPPER (TOTAL)	8	5	3	6	*	11	16	*	32
CYANIDE (TOTAL)	3	0	0	.	*	.	.	*	.
LEAD (TOTAL)	8	1	0	3	*	3	3	*	3
MERCURY (TOTAL)	8	3	0	0.40	*	0.55	1.80	*	4.30
NICKEL (TOTAL)	8	3	3	59	*	59	83	*	130
SELENIUM (TOTAL)	8	3	0	1	*	2	5	*	9
SILVER (TOTAL)	8	3	2	8	*	17	22	*	31
THALLIUM (TOTAL)	8	0	0	.	*	.	.	*	.
ZINC (TOTAL)	8	6	6	19	*	38	56	*	180

Table VI-6 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY ASSOCIATED AREAS
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	MIN	DETECTED CONCENTRATIONS IN UG/L				
				10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	6	6	6000	*	18400	24897	*	62000
PH (UNITS)	6	6	7.2	*	7.6	8.0	*	9.7
IRON (TOTAL)	6	8	205	*	620	1760	*	9500
MANGANESE (TOTAL)	8	7	27	*	348	1775	*	6300
COD	3	3	15500	*	17217	21178	*	29100
DISSOLVED SOLIDS	3	3	1550E3	*	1625E3	1717E3	*	1900E3
TOTAL VOLATILE SOLIDS	3	3	26000	*	31000	40111	*	58333
VOLATILE SUSPENDED SOLIDS	2	2	4800	*	4800	12200	*	19500
SETTLEABLE SOLIDS	4	4	0.0	*	0.0	0.1	*	0.1
TOTAL ORGANIC CARBON	3	2	5500	*	5500	6567	*	7633
NO ALKALINITY (CACO3)	3	3	25000	*	34500	64167	*	123500
PHENOLICS(4AAP)	3	0		*	.	.	*	.
SULFATE	1	1	170000	*	170000	170000	*	170000
TOTAL SOLIDS	2	2	180000	*	180000	220000	*	280000

Table VI-7

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY AREAS UNDER RECLAMATION
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ANTIMONY (TOTAL)	14	11	11	52	53	78	100	118	255
ARSENIC (TOTAL)	14	2	2	42	*	42	49	*	55
BERYLLIUM (TOTAL)	14	5	0	1	*	1	2	*	3
CADMIUM (TOTAL)	14	3	0	6	*	7	7	*	8
CHROMIUM (TOTAL)	14	8	5	6	*	9	12	*	24
COPPER (TOTAL)	14	11	8	5	5	15	17	28	41
LEAD (TOTAL)	14	0	0	.	*	.	.	*	.
MERCURY (TOTAL)	14	0	0	.	*	.	.	*	.
NICKEL (TOTAL)	14	3	3	71	*	82	115	*	182
SELENIUM (TOTAL)	14	2	2	42	*	42	60	*	77
SILVER (TOTAL)	14	4	0	6	*	6	6	*	7
THALLIUM (TOTAL)	14	3	3	12	*	23	61	*	137
ZINC (TOTAL)	14	14	14	8	9	32	71	187	382

Table VI-7 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
FINAL EFFLUENT
SUBCATEGORY AREAS UNDER RECLAMATION
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
TOTAL SUSPENDED SOLIDS	15	15	10400	11004	21675	29845	46125	81969
PH (UNITS)	15	15	5.5	6.0	7.5	7.4	7.9	8.0
IRON (TOTAL)	15	15	302	315	814	2101	5457	11205
MANGANESE (TOTAL)	14	14	77	84	235	828	911	6940
SETTLEABLE SOLIDS	12	5	0.0	*	0.1	3.1	*	14.8

Table VI-8

COAL MINING POINT SOURCE CATEGORY ORGANIC PRIORITY POLLUTANTS DETERMINED TO BE EXCLUDED

Pollutant	Not Detected	Believed to be from Contamination	Detected But Always Below 10 ug/l	Detected in Amounts too Small to Be Effectively Reduced
acenaphthene	x			
acrolein	x			
acrylonitrile	x			
benzene		x		
benzidine	x			
carbon tetrachloride (tetrachloromethane)	x			
chlorobenzene	x			
1,2,4-trichlorobenzene	x			
hexachlorobenzene	x			
1,2-dichloroethane			x	
1,1,1-trichloroethane				x
hexachloroethane			x	
1,1-dichloroethane	x			
1,1,2-trichloroethane	x			
1,1,2,2-tetrachloroethane			x	
chloroethane	x			
bis(chloromethyl)ether	x			
bis(2-chloroethyl)ether	x			

Table VI-8 (Continued)

.OAL MINING POINT SOURCE CATEGORY ORGANIC PRIORITY POLLUTANTS DETERMINED TO BE EXCLUDED

Pollutant	Not Detected	Believed to be from Contamination	Detected But Always Below 10 ug/1	Detected in Amounts too Small to Be Effectively Reduced
2-chloroethyl vinyl ether (mixed)	x			
2-chloronaphthalene	x			
2,4,6-trichlorophenol	x			
parachlorometa cresol	x			
chloroform (trichloromethane)		x		
2-chlorophenol	x			
1,2-dichlorobenzene				x
1,3-dichlorobenzene	x			
1,4-dichlorobenzene			x	
3,3'-dichlorobenzidine			x	
1,1-dichloroethylene				x
1,2-trans-dichloroethylene				x
2,4-dichlorophenol	x			
1,2-dichloropropane	x			
1,2-dichloropropylene (1,3-dichloropropene)	x			
2,4-dimethylphenol	x			

Table VI-8 (Continued)

COAL MINING POINT SOURCE CATEGORY ORGANIC PRIORITY POLLUTANTS DETERMINED TO BE EXCLUDED

Pollutant	Not Detected	Believed to be from Contamination	Detected But Always Below 10 ug/1	Detected in Amounts toc Small to Be Effectively Reduced
2,4-dinitrotoluene	x			
2,6-dinitrotoluene	x			
1,2-diphenylhydrazine	x			
ethylbenzene				x
fluoranthene			x	
4-chlorophenyl phenyl ether	x			
4-bromophenyl phenyl ether	x			
bis(2-chloroisopropyl) ether	x			
bis(2-chloroethoxy) methane			x	
methylene chloride (dichloromethane)		x		
methyl chloride (chloromethane)	x			
methyl bromide (bromomethane)	x			
bromoform	x			

Table VI-8 (Continued)

COAL MINING POINT SOURCE CATEGORY ORGANIC PRIORITY POLLUTANTS DETERMINED TO BE EXCLUDED

Pollutant	Not Detected	Believed to be from Contamination	Detected But Always Below 10 ug/l	Detected in Amounts too Small to Be Effectively Reduced
dichlorobromomethane	x			
trichlorofluoromethane				
dichlorodifluoromethane	x			x
chlorodibromomethane	x			
hexachlorobutadiene	x			
hexachlorocyclopentadiene	x			
isophorone	x			
naphthalene				
nitrobenzene	x			x
2-nitrophenol	x			
4-nitrophenol	x			
2,4-dinitrophenol				
4,6-dinitro-o-cresol			x	
N-nitrosodimethylamine	x		x	
N-nitrosodiphenylamine	x			
N-nitrosodi-n-propylamine	x			
pentachlorophenol				
phenol		x	x	

Table VI-8 (Continued)

COAL MINING POINT SOURCE CATEGORY ORGANIC PRIORITY POLLUTANTS DETERMINED TO BE EXCLUDED

Pollutant	Not Detected	Believed to be from Contamination	Detected But Always Below 10 ug/1	Detected in Amounts too Small to Be Effectively Reduced
bis(2-ethylhexyl) phthalate		x		
butyl benzyl phthalate		x		
di-n-butyl phthalate		x		
di-n-octyl phthalate			x	
diethyl phthalate		x		
dimethyl phthalate	x			
benzo(a)anthracene (1,2-benzanthracene)			x	
benzo(a)pyrene(3,4-benzopyrene)	x			
3,4-benzofluoranthene	x			
benzo(k)fluoranthene (11,12-benzofluoranthene)	x			
chrysene			x	
acenaphthylene	x			
anthracene			x	
benzo(g,h,i)perylene (1,12-benzoperylene)			x	

Table VI-8 (Continued)

COAL MINING POINT SOURCE CATEGORY ORGANIC PRIORITY POLLUTANTS
DETERMINED TO BE EXCLUDED

Pollutant	Not Detected	Believed to be from Contamination	Detected But Always Below 10 ug/1	Detected in Amounts too Small to Be Effectively Reduced
fluorene			x	
phenanthrene			x	
dibenzo(a,h)anthracene (1,2,5,6-dibenzanthracene)				x
indeno(1,2,3-c,d)pyrene (phenylenepyrene)				x
pyrene			x	
tetrachloroethylene		x		
toluene		x		
vinyl chloride (chloroethylene)	x			
trichloroethylene				x
aldrin			x	
dieldrin	x			
chlordane (technical (mixture and metabolites)	x			
4,4'-DDT			x	
4,4'-DDE (p,p'-DDX)	x			
4,4'-DDD (p,p'-TDE)			x	
-endosulfan-Alpha	x			

Table VI-8 (Continued)

COAL MINING POINT SOURCE CATEGORY ORGANIC PRIORITY POLLUTANTS DETERMINED TO BE EXCLUDED

Pollutant	Not Detected	Believed to be from Contamination	Detected But Always Below 10 ug/1	Detected in Amounts too Small to Be Effectively Reduced
-endosulfan-Beta	x			
endosulfan sulfate	x			
endrin	x			
endrin aldehyde	x			
heptachlor			x	
heptachlor epoxide			x	
-BHC-Alpha				x
-BHC-Beta				x
-BHC-(lindane)-Gamma				x
-BHC-Delta				x
PCB 1242 (Arochlor 1242)	x			
PCB-1254 (Arochlor 1254)	x			
PCB-1221 (Arochlor 1221)	x			
PCB-1232 (Arochlor 1232)	x			
PCB-1248 (Arochlor 1248)	x			
PCB-1260 (Arochlor 1260)	x			
PCB-1016 (Arochlor 1016)	x			
toxaphene	x			
2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)	x			

Table VI-9

PRIORITY ORGANICS NOT DETECTED IN TREATED EFFLUENTS OF SCREENING AND VERIFICATION SAMPLES

1. acenaphthene
2. acrolein
3. acrylonitrile
4. benzidine
5. carbon tetrachloride (tetrachloromethane)
6. chlorobenzene
7. 1,2,4-trichlorobenzene
8. hexachlorobenzene
9. 1,1-dichloroethane
10. 1,1,2-trichloroethane
11. chloroethane
12. bis(chloromethyl) ether
13. bis(2-chloroethyl) ether
14. 2-chloroethyl vinyl ether (mixed)
15. 2-chloronaphthalene
16. 2,4,6-trichlorophenol
17. parachlorometa cresol
18. 2-chlorophenol
19. 1,3-dichlorobenzene
20. 2,4-dichlorophenol
21. 1,2-dichloropropane
22. 1,2-dichloropropylene (1,3-dichloropropene)
23. 2,4-dimethylphenol
24. 2,4-dinitrotoluene
25. 2,6-dinitrotoluene
26. 1,2-diphenylhydrazine
27. bis(2-chloroisopropyl) ether
28. 4-chlorophenyl phenyl ether

Table VI-9 (Continued)

PRIORITY ORGANICS NOT DETECTED IN TREATED EFFLUENTS OF SCREENING AND VERIFICATION SAMPLES

29. 4-bromophenyl phenyl ether
30. methyl chloride (chloromethane)
31. methyl bromide (bromomethane)
32. bromoform (tribromomethane)
33. dichlorobromomethane
34. dichlorodifluoromethane
35. chlorodibromomethane
36. hexachlorobutadiene
37. hexachlorocyclopentadiene
38. isophorone
39. nitrobenzene
40. 2-nitrophenol
41. 4-nitrophenol
42. N-nitrosodimethylamine
43. N-nitrosodiphenylamine
44. N-nitrosodi-n-propylamine
45. dimethyl phthalate
46. benzo(a)pyrene
47. 3,4-benzofluoranthene
48. benzo(k)fluoranthane(11,12-benzofluoranthene)
49. acenaphthylene
50. vinyl chloride (chloroethylene)
51. dieldrin

Table VI-9 (Continued)

PRIORITY ORGANICS NOT DETECTED IN TREATED EFFLUENTS OF SCREENING AND VERIFICATION SAMPLES

52. chlordane (technical mixture and metabolites)
53. 4,4'-DDE (p,p'-DDX)
54. α-endosulfan-Alpha
55. β-endosulfan-Beta
56. endosulfan sulfate
57. endrin
58. endrin aldehyde
59. PCB 1242 (Arochlor 1242)
60. PCB 1254 (Arochlor 1254)
61. PCB 1221 (Arochlor 1221)
62. PCB 1232 (Arochlor 1232)
63. PCB 1248 (Arochlor 1248)
64. PCB 1260 (Arochlor 1260)
65. PCB 1016 (Arochlor 1016)
66. toxaphene
67. 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD)

Table VI-10

PRIORITY ORGANICS DETECTED BUT PRESENT DUE TO CONTAMINATION OF SOURCES OTHER THAN THOSE SAMPLES SCREENING AND VERIFICATION SAMPLES

1. benzene
2. chloroform
3. methylene chloride
4. phenol
5. bis(2-ethylhexyl)phthalate
6. butyl benzyl phthalate
7. di-n-butyl phthalate
8. diethyl phthalate
9. tetrachloroethylene
10. toluene

Verification, and EPA Regional Sampling and Analysis). The field controls consisted of water that was run through the automatic sampler for each composite sample site prior to the actual sampling. The water used as control water was deionized and as such, any contaminants appearing in the collected control water could be attributed to the sampling apparatus or to the laboratory analysis. The results for field control samples are found for all subcategories in Table VI-11. Field blanks were also collected to assess contamination in transport and in laboratory analysis. For the volatile organics, deionized water was periodically placed in 45 ml to 125 ml vials and shipped to the laboratory for analysis. For the remainder of the priority pollutants, a facility blank, prepared in the laboratory, was hand-carried by sampling personnel during field sampling. Table VI-12 summarizes the blanks for the screening and verification sampling and analysis program. Table VI-2 indicates that members of the phthalate class were observed in many of the samples representing treated wastewater.

Only two of the phthalates (bis-phthalate and di-n-butyl phthalate) were detected in the raw water (refer to Table V-4); however, five of the phthalates (bis-phthalate, di-n-butyl phthalate, butyl benzyl phthalate, di-n-octyl phthalate, and diethyl phthalate) were detected in treated water. This suggests that these compounds were introduced into the water during sample collection or analysis. It is known that during sample collection, automatic composite samplers were equipped with polyvinyl chloride (Tygon) tubing or manufacturer supplied tubing. Phthalates are widely used as plasticizers to ensure that tubing remains soft and flexible (2). These compounds, added during manufacturing, have a tendency to migrate to the surface of tubing and leach out into water passing through the sample tubing. In addition, laboratory experiments were performed to determine if phthalates and other priority pollutants could be leached from tubing used on automatic samplers (3). The types of tubing used in these experiments were: (1) Clear tubing originally supplied with the sampler at time of purchase; and (2) Tygon S-50-HL, Class VI. Results of analysis of the extracts representing the original and replacement Tygon tubings are summarized in Table VI-13. The data indicate that both types contain bis(2-ethylhexyl)phthalate and the original tubing leaches high concentrations of phenol. Although bis(2-ethylhexyl)phthalate was the only phthalate detected in the tubing in these experiments, a similar experiment conducted as part of a study pursuant to the development of BAT Effluent Limitations Guidelines for the Textiles Point Source Category found dimethyl phthalate, diethyl phthalate, di-n-butyl phthalate, and bis(2-ethylhexyl)phthalate, in tubing "controls" (4). Thus, four of the phthalates bis(2-ethylhexyl)phthalate, butylbenzyl phthalate, di-n-butyl phthalate, diethyl phthalate and phenol can be attributed to contamination during sample collection and cannot be conclusively identified with the wastewater.

A number of the volatile organic compounds were detected during the sampling program (benzene, chloroform, methylene chloride, tetrachloroethylene, toluene). The volatile nature of these compounds

Table VI-11

WASTEWATER CHARACTERIZATION SUMMARY
CONTROLS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	44	0	0	.	*	.	.	*	.
ACROLEIN	10	0	0	.	*	.	.	*	.
ACRYLONITRILE	10	0	0	.	*	.	.	*	.
BENZENE	10	5	5	21	*	27	52	*	158
BENZIDENE	44	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	10	0	0	.	*	.	.	*	.
CHLOROBENZENE	10	0	0	.	*	.	.	*	.
1,2,3-TRICHLOROBENZENE	44	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	44	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	10	0	0	.	*	.	.	*	.
1,1,1-TRICHLOROETHANE	10	1	0	3	*	3	3	*	3
HEXACHLOROETHANE	44	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	10	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	10	0	0	.	*	.	.	*	.
1,1,2,2-TETRACHLOROETHANE	10	0	0	.	*	.	.	*	.
CHLOROETHANE	10	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	28	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	44	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	10	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	44	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	44	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	44	0	0	.	*	.	.	*	.
CHLOROFORM	10	2	1	3	*	3	25	*	47
2-CHLOROPHENOL	44	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	44	2	0	3	*	3	3	*	3
1,3-DICHLOROBENZENE	43	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	43	3	0	1	*	2	2	*	3
3,3-DICHLOROBENZIDINE	44	0	0	.	*	.	.	*	.

Table VI-11 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
CONTROLS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	10	0	0	.	*	.	.	*	.
1,2-TRANS-DICHLOROETHYLENE	10	0	0	.	*	.	.	*	.
2,4-DICHLOROPHENOL	44	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	10	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	10	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	44	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	44	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	44	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	44	0	0	.	*	.	.	*	.
ETHYLBENZENE	10	0	0	.	*	.	.	*	.
FLUORANTHENE	44	1	0	3	*	3	3	*	3
4-CHLOROPHENYL PHENYL ETHER	44	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	44	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	44	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	44	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	10	9	7	3	*	282	389	*	880
METHYL CHLORIDE	10	0	0	.	*	.	.	*	.
METHYL BROMIDE	10	0	0	.	*	.	.	*	.
BROMOFORM	10	0	0	.	*	.	.	*	.
DICHLOROBROMOMETHANE	10	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	10	0	0	.	*	.	.	*	.
DICHLORODIFLUOROMETHANE	10	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	10	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	44	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	44	0	0	.	*	.	.	*	.
ISOPHORONE	44	0	0	.	*	.	.	*	.
NAPHTHALENE	44	1	0	3	*	3	3	*	3
NITROBENZENE	44	0	0	.	*	.	.	*	.

Table VI-11 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
CONTROLS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	44	0	0	.	*	.	.	*	.
4-NITROPHENOL	44	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	44	1	0	4	*	4	4	*	4
4,6-DINITRO-O-CRESOL	44	1	0	6	*	6	6	*	6
N-NITROSODIMETHYLAMINE	44	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	44	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	44	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	44	0	0	.	*	.	.	*	.
PHENOL	44	2	0	3	*	3	3	*	3
BIS(2-ETHYLHEXYL) PHTHALATE	44	18	14	3	3	215	453	1210	1600
BUTYL BENZYL PHTHALATE	44	2	0	3	*	3	3	*	3
DI-N-BUTYL PHTHALATE	44	13	7	1	1	9	275	880	1100
DI-N-OCTYL PHTHALATE	44	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	44	5	0	1	*	2	2	*	3
DIMETHYL PHTHALATE	44	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	44	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	44	0	0	.	*	.	.	*	.
BENZO(B)FLUORANTHENE	44	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	44	0	0	.	*	.	.	*	.
CHRYSENE	44	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	44	0	0	.	*	.	.	*	.
ANTHRACENE	29	1	0	3	*	3	3	*	3
BENZO(G,H,I)PERYLENE	44	1	0	3	*	3	3	*	3
FLUORENE	44	0	0	.	*	.	.	*	.
PHENANTHRENE	29	1	0	3	*	3	3	*	3
DIBENZO(A,H)ANTHRACENE	44	1	0	3	*	3	3	*	3
INDENO(1,2,3-C,D)PYRENE	44	1	0	3	*	3	3	*	3
PYRENE	44	1	0	3	*	3	3	*	3

Table VI-11 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
CONTROLS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	10	0	0	.	*	.	.	*	.
TOLUENE	10	6	5	3	*	25	41	*	146
TRICHLOROETHYLENE	10	1	0	3	*	3	3	*	3
VINYL CHLORIDE	10	0	0	.	*	.	.	*	.
ALDRIN	37	2	0	3.16	*	3.16	3.16	*	3.16
DIELDRIN	37	1	0	3.16	*	3.16	3.16	*	3.16
CHLORDANE	37	0	0	.	*	.	.	*	.
4,4-DDT	37	0	0	.	*	.	.	*	.
4,4-DDE	37	1	0	3.16	*	3.16	3.16	*	3.16
4,4-DDD	37	1	0	3.16	*	3.16	3.16	*	3.16
ENDOSULFAN-ALPHA	37	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	37	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	37	0	0	.	*	.	.	*	.
ENDRIN	37	1	0	3.16	*	3.16	3.16	*	3.16
ENDRIN ALDEHYDE	37	0	0	.	*	.	.	*	.
HEPTACHLOR	37	1	0	3.16	*	3.16	3.16	*	3.16
HEPTACHLOR EPOXIDE	37	2	0	3.16	*	3.16	3.16	*	3.16
BHC-ALPHA	37	2	0	3.16	*	3.16	3.16	*	3.16
BHC-BETA	37	0	0	.	*	.	.	*	.
BHC (LINDANE)-GAMMA	37	1	0	3.16	*	3.16	3.16	*	3.16
BHC-DELTA	37	2	0	3.16	*	3.16	3.16	*	3.16
PCB-1242 (AROCHLOR 1242)	37	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	37	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	37	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	37	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	37	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	37	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	37	0	0	.	*	.	.	*	.

Table VI-11 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
CONTROLS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	37	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	27	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	20	0	0	.	*	.	.	*	.
ANTIMONY (TOTAL)	19	2	0	1	*	1	1	*	1
ARSENIC (TOTAL)	19	10	0	1	1	2	2	3	5
BERYLLIUM (TOTAL)	20	0	0	.	*	.	.	*	.
CADMIUM (TOTAL)	20	1	1	20	*	20	20	*	20
CHROMIUM (TOTAL)	20	1	1	30	*	30	30	*	30
COPPER (TOTAL)	20	9	4	5	*	8	17	*	58
LEAD (TOTAL)	20	5	5	86	*	100	102	*	115
MERCURY (TOTAL)	20	17	0	0.10	0.10	0.35	0.99	3.18	3.90
NICKEL (TOTAL)	20	2	2	50	*	50	50	*	50
SELENIUM (TOTAL)	20	6	0	0	*	2	2	*	2
SILVER (TOTAL)	20	0	0	.	*	.	.	*	.
THALLIUM (TOTAL)	20	3	0	1	*	1	1	*	1
ZINC (TOTAL)	20	10	10	27	27	38	108	300	380

Table VI-11 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
CONTROLS
ALL SUBCATEGORIES
CONVENTIONAL AND NONCONVENTIONAL POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECTS	DETECTED CONCENTRATIONS IN UG/L					
			MIN	10%	MEDIAN	MEAN	90%	MAX
IRON (TOTAL)	20	18	43	51	118	4036	4422	50000
MANGANESE (TOTAL)	20	6	10	*	15	46	*	190
PHENOLICS(4AAP)	1	0	.	*	.	.	*	.

Table VI-12

WASTEWATER CHARACTERIZATION SUMMARY
PLANT BLANKS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
ACENAPHTHENE	21	0	0	.	*	.	.	*	.
ACROLEIN	11	0	0	.	*	.	.	*	.
ACRYLONITRILE	11	0	0	.	*	.	.	*	.
BENZENE	11	9	3	1	*	3	18	*	110
BENZIDENE	21	0	0	.	*	.	.	*	.
CARBON TETRACHLORIDE	11	0	0	.	*	.	.	*	.
CHLOROBENZENE	11	2	0	3	*	3	3	*	3
1,2,3-TRICHLOROBENZENE	21	0	0	.	*	.	.	*	.
HEXACHLOROBENZENE	21	0	0	.	*	.	.	*	.
1,2-DICHLOROETHANE	11	2	0	1	*	1	2	*	3
1,1,1-TRICHLOROETHANE	11	2	0	1	*	1	1	*	2
HEXACHLOROETHANE	21	0	0	.	*	.	.	*	.
1,1-DICHLOROETHANE	11	0	0	.	*	.	.	*	.
1,1,2-TRICHLOROETHANE	11	1	0	3	*	3	3	*	3
1,1,2,2-TETRACHLOROETHANE	11	1	0	3	*	3	3	*	3
CHLOROETHANE	11	0	0	.	*	.	.	*	.
BIS(CHLOROMETHYL) ETHER	10	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHYL) ETHER	21	0	0	.	*	.	.	*	.
2-CHLOROETHYL VINYL ETHER (MIXED)	11	0	0	.	*	.	.	*	.
2-CHLORONAPHTHALENE	21	0	0	.	*	.	.	*	.
2,4,6-TRICHLOROPHENOL	21	0	0	.	*	.	.	*	.
PARACHLOROMETA CRESOL	21	0	0	.	*	.	.	*	.
CHLOROFORM	11	11	6	3	3	11	26	52	130
2-CHLOROPHENOL	21	0	0	.	*	.	.	*	.
1,2-DICHLOROBENZENE	21	0	0	.	*	.	.	*	.
1,3-DICHLOROBENZENE	21	0	0	.	*	.	.	*	.
1,4-DICHLOROBENZENE	21	0	0	.	*	.	.	*	.
3,3-DICHLOROBENZIDINE	21	0	0	.	*	.	.	*	.

Table VI-12 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
PLANT BLANKS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
1,1-DICHLOROETHYLENE	11	0	0	.	*	.	.	*	.
1,2-TRANS-DICHLOROETHYLENE	11	2	0	1	*	1	2	*	2
2,4-DICHLOROPHENOL	21	0	0	.	*	.	.	*	.
1,2-DICHLOROPROPANE	11	0	0	.	*	.	.	*	.
1,3-DICHLOROPROPENE	11	0	0	.	*	.	.	*	.
2,4-DIMETHYLPHENOL	21	0	0	.	*	.	.	*	.
2,4-DINITROTOLUENE	21	0	0	.	*	.	.	*	.
2,6-DINITROTOLUENE	21	0	0	.	*	.	.	*	.
1,2-DIPHENYLHYDRAZINE	21	0	0	.	*	.	.	*	.
ETHYLBENZENE	11	4	1	1	*	2	6	*	20
FLUORANTHENE	21	0	0	.	*	.	.	*	.
4-CHLOROPHENYL PHENYL ETHER	21	0	0	.	*	.	.	*	.
4-BROMOPHENYL PHENYL ETHER	21	0	0	.	*	.	.	*	.
BIS(2-CHLOROISOPROPYL) ETHER	21	0	0	.	*	.	.	*	.
BIS(2-CHLOROETHOXY) METHANE	21	0	0	.	*	.	.	*	.
METHYLENE CHLORIDE (DICHLOROMETHANE)	11	10	9	3	3	2500	5321	11000	23000
METHYL CHLORIDE	11	0	0	.	*	.	.	*	.
METHYL BROMIDE	11	0	0	.	*	.	.	*	.
BROMOFORM	11	1	0	3	*	3	3	*	3
DICHLOROBROMOMETHANE	11	0	0	.	*	.	.	*	.
TRICHLOROFLUOROMETHANE	11	6	6	13	*	25	29	*	50
DICHLORODIFLUOROMETHANE	11	0	0	.	*	.	.	*	.
CHLORODIBROMOMETHANE	11	0	0	.	*	.	.	*	.
HEXACHLOROBUTADIENE	21	0	0	.	*	.	.	*	.
HEXACHLOROCYCLOPENTADIENE	21	0	0	.	*	.	.	*	.
ISOPHORONE	21	0	0	.	*	.	.	*	.
NAPHTHALENE	21	0	0	.	*	.	.	*	.
NITROBENZENE	21	0	0	.	*	.	.	*	.

Table VI-12 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
PLANT BLANKS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
2-NITROPHENOL	21	0	0	.	*	.	.	*	.
4-NITROPHENOL	21	0	0	.	*	.	.	*	.
2,4-DINITROPHENOL	21	0	0	.	*	.	.	*	.
4,6-DINITRO-O-CRESOL	21	0	0	.	*	.	.	*	.
N-NITROSODIMETHYLAMINE	21	0	0	.	*	.	.	*	.
N-NITROSODIPHENYLAMINE	21	0	0	.	*	.	.	*	.
N-NITROSODI-N-PROPYLAMINE	21	0	0	.	*	.	.	*	.
PENTACHLOROPHENOL	21	0	0	.	*	.	.	*	.
PHENOL	21	0	0	.	*	.	.	*	.
BIS(2-ETHYLHEXYL) PHTHALATE	21	4	4	16	*	840	989	*	1600
BUTYL BENZYL PHTHALATE	21	0	0	.	*	.	.	*	.
DI-N-BUTYL PHTHALATE	21	1	1	220	*	220	220	*	220
DI-N-OCTYL PHTHALATE	21	0	0	.	*	.	.	*	.
DIETHYL PHTHALATE	21	0	0	.	*	.	.	*	.
DIMETHYL PHTHALATE	21	0	0	.	*	.	.	*	.
BENZO(A)ANTHRACENE	21	0	0	.	*	.	.	*	.
BENZO(A)PYRENE	21	0	0	.	*	.	.	*	.
BENZO(B)FLUORANTHENE	21	0	0	.	*	.	.	*	.
BENZO(K)FLUORANTHENE	21	0	0	.	*	.	.	*	.
CHRYSENE	21	0	0	.	*	.	.	*	.
ACENAPHTHYLENE	21	0	0	.	*	.	.	*	.
ANTHRACENE	21	0	0	.	*	.	.	*	.
BENZO(G,H,I)PERYLENE	21	0	0	.	*	.	.	*	.
FLUORENE	21	0	0	.	*	.	.	*	.
PHENANTHRENE	21	0	0	.	*	.	.	*	.
DIBENZO(A,H)ANTHRACENE	21	0	0	.	*	.	.	*	.
INDENO(1,2,3-C,D)PYRENE	21	0	0	.	*	.	.	*	.
PYRENE	21	0	0	.	*	.	.	*	.

Table VI-12 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
PLANT BLANKS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L MIN	10%	MEDIAN	MEAN	90%	MAX
TETRACHLOROETHYLENE	11	8	3	1	*	8	15	*	40
TOLUENE	11	10	2	3	3	5	20	70	92
TRICHLOROETHYLENE	11	1	0	3	*	3	3	*	3
VINYL CHLORIDE	11	0	0	.	*	.	.	*	.
ALDRIN	21	0	0	.	*	.	.	*	.
DIELDRIN	21	0	0	.	*	.	.	*	.
CHLORDANE	21	0	0	.	*	.	.	*	.
4,4-DDT	21	0	0	.	*	.	.	*	.
4,4-DDE	21	0	0	.	*	.	.	*	.
4,4-DDD	21	0	0	.	*	.	.	*	.
ENDOSULFAN-ALPHA	21	0	0	.	*	.	.	*	.
ENDOSULFAN-BETA	21	0	0	.	*	.	.	*	.
ENDOSULFAN SULFATE	21	0	0	.	*	.	.	*	.
ENDRIN	21	0	0	.	*	.	.	*	.
ENDRIN ALDEHYDE	21	0	0	.	*	.	.	*	.
HEPTACHLOR	21	0	0	.	*	.	.	*	.
HEPTACHLOR EPOXIDE	21	0	0	.	*	.	.	*	.
BHC-ALPHA	21	0	0	.	*	.	.	*	.
BHC-BETA	21	0	0	.	*	.	.	*	.
BHC (LINDANE)-GAMMA	21	0	0	.	*	.	.	*	.
BHC-DELTA	21	0	0	.	*	.	.	*	.
PCB-1242 (AROCHLOR 1242)	21	0	0	.	*	.	.	*	.
PCB-1254 (AROCHLOR 1254)	21	0	0	.	*	.	.	*	.
PCB-1221 (AROCHLOR 1221)	21	0	0	.	*	.	.	*	.
PCB-1232 (AROCHLOR 1232)	21	0	0	.	*	.	.	*	.
PCB-1248 (AROCHLOR 1248)	21	0	0	.	*	.	.	*	.
PCB-1260 (AROCHLOR 1260)	21	0	0	.	*	.	.	*	.
PCB-1016 (AROCHLOR 1016)	21	0	0	.	*	.	.	*	.

Table VI-12 (Continued)

WASTEWATER CHARACTERIZATION SUMMARY
PLANT BLANKS
ALL SUBCATEGORIES
TOXIC POLLUTANTS

COMPOUND	TOTAL NUMBER SAMPLES	TOTAL NUMBER DETECT	NUMBER SAMPLES >10UG/L	DETECTED CONCENTRATIONS IN UG/L					
				MIN	10%	MEDIAN	MEAN	90%	MAX
TOXAPHENE	21	0	0	.	*	.	.	*	.
2,3,7,8-TETRACHLORODIBENZO-P-DIOXIN	21	0	0	.	*	.	.	*	.
ANTHRACENE/PHENANTHRENE	21	0	0	.	*	.	.	*	.

Table VI-13 (3)

TUBING LEACHING ANALYSIS RESULTS

Component	Micrograms/Liter	
	Original ISCO	Tygon
Bis (2-ethylhexyl) Phthalate		
Acid Extract	915	N.D.
Base-Neutral Extract	2,070	885
Phenol		
Acid Extract	19,650	N.D.
Base-Neutral Extract	N.D.	N.D.

N.D. - Not Detected

suggests contamination as a possible source, especially considering the relatively low concentrations detected in the samples. More importantly, all of these compounds may be found in the laboratory as solvents, extraction agents or aerosol propellants. Thus, the presence and/or use of the compounds in the laboratory may be responsible for sample contamination. This type of contamination has been previously addressed in another study (5). In a review of a set of volatile organic blank analytical data from this study, inadvertent contamination was shown to have occurred for each of the above compounds (see Table VI-12).

Another contaminant is methylene chloride. This compound is separated and quantified with other volatile compounds. The organics analytical procedure involves the use of methylene chloride as a solvent (1), (5). Thus, the relatively high concentrations and the detection of this compound in 47 of 51 of the treated water samples (Table VI-2) may be explained by its use in analytical procedures.

Priority Organics Detected in Treated Effluents at One or Two Mines and Uniquely Related to Those Sources

The 23 pollutants in Table VI-14 were detected at two or fewer facilities and always at concentrations below 10 ug/l. One of these compounds is a member of the phthalate family, two are volatile organics, three are acid-extractable, twelve are base neutrals and five are pesticides. These organics are excluded from regulation since they are present at less than the nominal detection limit (10 ug/l) in two or less facilities within the category. This level was established by the Agency to indicate where background signals in the machines used for analysis begin to mask actual detection signals (i.e., the signal to noise ratio reaches approximately 2:1). Examination of Tables VI-11 and VI-12 shows that 14 of these compounds were also detected in at least one field blank or control sample.

Priority Organics Detected but Present in Amounts too Small to be Effectively Reduced

The 14 compounds in Table VI-15 were detected in treated effluents in this industry. The concentrations of these pollutants are so small that they cannot be substantially reduced. In some cases this is because no technologies are known to further reduce them beyond those of BPT; in other cases, the pollutant reduction cannot be accurately quantified because the analytical error at these low levels can be larger than the value itself. These 14 pollutants are thus excluded from regulation. Therefore, all pollutants listed in Table VI-8 were determined to be excluded from regulation at this time.

Table VI-14

COMPOUNDS DETECTED IN TREATED WATER
AT ONE OR TWO MINES
BUT ALWAYS BELOW 10 ug/l

1. *1,2-dichloroethane
2. hexachloroethane
3. *1,1,2,2-tetrachloroethane
4. *1,4-dichlorobenzene
5. 3,3'-dichlorobenzidine
6. *fluoranthene
7. bis(2-chloroethoxy) methane
8. *2,4-dinitrophenol
9. *4,6-dinitro-o-cresol
10. pentachlorophenol
11. di-n-octyl phthalate
12. benzo(a)anthracene
13. chrysene
14. *anthracene
15. fluorene
16. *phenanthrene
17. *pyrene
18. *benzo(g,h,i)perylene
19. *aldrin
20. 4,4'-DDT
21. *4,4'-DDD
22. *heptachlor
23. *heptachlor epoxide

*This compound was detected in one or more field blanks and/or controls.

Table VI-15

PRIORITY ORGANICS DETECTED BUT PRESENT IN AMOUNTS TOO SMALL TO BE EFFECTIVELY REDUCED

1. 1,1,1,-trichloroethane
2. 1,1-dichloroethylene
3. 1,2-trans-dichloroethylene
4. ethylbenzene
5. trichlorofluoromethane
6. trichloroethylene
7. 1,2-dichlorobenzene
8. naphthalene
9. dibenzo (a,h) anthracene
10. indeno (1,2,3-c,d) pyrene
11. BHC-Alpha
12. BHC-Beta
13. BHC-Gamma
14. BHC-Delta

PRIORITY METALS EXCLUDED FROM REGULATION

All of the priority metals have been excluded from regulation. Examination of Table VI-2 shows that five priority metals (antimony, beryllium, cadmium, silver and thallium) and cyanide were detected in effluents at more than two facilities. However, in all cases the detected concentrations were at levels only slightly above the detection limit for each respective species. This precludes any meaningful determination of the effectiveness of treatment beyond BPT technologies. Thus, antimony, beryllium, cadmium, cyanide, silver and thallium can be excluded from BAT regulation since they cannot be effectively reduced by known technologies.

The remaining eight (arsenic, chromium, copper, lead, mercury, nickel, selenium, and zinc) were sometimes found at concentrations above the detection limit in BPT-treated discharges as also shown in Table VI-2. Paragraph 8(a)(iii) provides for exclusion of pollutants if these pollutants are already effectively controlled by technologies upon which other effluent limitations and guidelines are based. It is the Agency's opinion that these eight metals are in generally low enough concentrations such that they are effectively controlled by BPT technology and thus were not selected for national regulation under BAT or NSPS. However, some of these metals appear in significant amounts for individual mines. This results from a number of factors, including: (1) Differing trace element compositions in the precursor plant life that was later transformed into coal, (2) Differing geologies of strata surrounding the coal, and (3) Geographic variations. In these cases, the permit authority should consider the imposition of a limitation for the pollutant of concern for the mine in question.

SECTION VII

TREATMENT AND CONTROL TECHNOLOGY

INTRODUCTION

Previous sections have presented the characteristics of raw and treated effluents in the coal mining industry, including the priority, conventional, and nonconventional pollutants present in these wastewaters. This section presents the existing treatment practices of the coal mining industry (which should reflect, at a minimum, BPT or equivalent technology), the candidate BAT treatment and control technologies, and the associated levels of conventional, nonconventional and toxic pollutant reduction. These control practices will be evaluated only from a technical standpoint; cost considerations will be presented in Section VIII.

APPROACH

A summary of in-use treatment technology (BPT or its equivalent) is presented in this section for each subcategory. Next, the candidate treatment technologies applicable to BPT-treated effluents in each subcategory are reviewed. To determine the best available technology, all potentially available treatment techniques were assessed according to a number of initial criteria. These initial screening criteria are:

1. The candidate technology must produce or be capable of producing an effluent of better quality than that required under BPT guidelines.

2. The candidate technology must be in use or available to the coal mining industry or transferable from other industrial or municipal wastewater treatment applications.

3. Preliminary cost studies or cost data must be available; this information should indicate baseline cost feasibility of the candidate technology.

Applying these initial criteria, the following candidate technologies were selected:

1. Flocculant Addition,
2. Granular Media Filtration,
3. Carbon Adsorption,
4. Ion Exchange,
5. Reverse Osmosis,
6. Electrodialysis,
7. Ozonation, and
8. Sulfide Precipitation.

Next, the technical feasibility of these technologies was assessed based on the following criteria:

1. Process fundamentals,
2. Control effectiveness,
3. Non-water quality impacts,
4. Reliability,
5. Secondary waste streams, and
6. Preliminary cost/economic considerations.

The process fundamentals description is a short summary highlighting the major operating parameters, equipment required, and the mechanism for pollutant reduction or removal. The degree of this reduction is presented as the control effectiveness for each technology, in tabular form where sufficient data exist.

The non-water quality impacts resulting from applications of a treatment technique are also discussed. These include sludge generation, air pollution, and energy requirements.

Another factor considered--reliability--is principally a function of the maturity of the technology; i.e., the degree to which the process has been commercialized and initial problems resolved. The generation of secondary waste streams, such as brines, are also important parameters in determining the merit of each technology. Finally, preliminary cost estimates were prepared to analyze the cost effectiveness of each candidate technology.

After reviewing the above aspects of each technology and, in particular, the preliminary cost and control effectiveness, appropriate candidate treatment technologies in each subcategory were selected.

The final screening step for the BATEA determination is application of cost and economic criteria. Cost estimates are first prepared for each technology not previously eliminated (these cost curves and supporting material are presented in Section VIII). The cost curves for each treatment system are then used as input to a computer economic model. This computer model will predict the nationwide economic impact by geographic region including total cost to the industry; changes in selling price of the commodity, productivity, employment, and number of operating facilities; and import/ export fluctuations. The results of this economic assessment are contained in a separate document entitled, "Economic Impact Analysis for Final Effluent Limitations and Standards for the Coal Mining Industries."

ACID MINE DRAINAGE

Current Treatment Technology

Raw wastewaters from mines exhibiting acid drainage are characterized by low pH and high levels of dissolved iron and other metals. Raw wastewaters from surface operations may carry substantial sediment loads. The effluent limitations currently in force can be achieved by application of the best practicable technology to these wastewaters. For this subcategory, this level of technology includes chemical precipitation/pH adjustment, aeration, and settling. A flow chart for a typical BPT treatment system is illustrated in Figure VII-1. Each of the principal process units is discussed below. The raw water holding pond, although not always installed, is employed by many facilities as an equalization basin. Variation in flow and pollutants, particularly pH, can be minimized by this pond. Overflow from this facility is then commonly routed to a mixing tank where pH adjustment is initiated.

pH Adjustment/Chemical Precipitation

This technology consists of the addition of an alkaline reagent to acid mine drainage to raise the pH to between six and nine. This pH change also causes the solubilities of positively charged metal ions to decrease and thus precipitate (settle as an insoluble compound) out of solution. These metal ions are replaced in solution by more acceptable calcium, magnesium and sodium ions. In general, three types of reactions occur as a result of pH adjustment:

1. Neutralization, an ion exchange reaction that, in the case of acid mine drainage, combines basic hydroxyl ions with acidic hydronium ions;

2. Oxidation, which converts ferrous iron (iron in the +2 valence state) to ferric iron (iron in the +3 valence state); and

3. Precipitation, which results from solubility decreases of toxic and other metal ions.

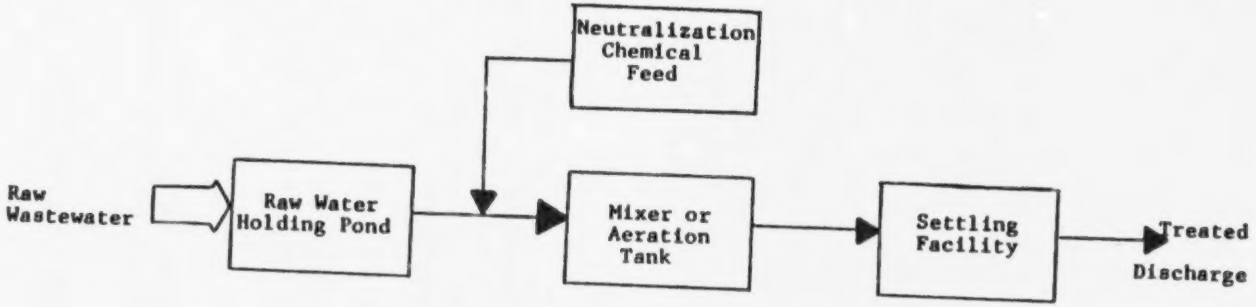


Figure VII-1
TYPICAL BPT TREATMENT CONFIGURATION FOR ACID MINE DRAINAGE

The precipitates are, in most cases, metal hydroxides such as ferric hydroxide ($Fe(OH)_3$) which can be removed to a great extent by settling. One of four reagents are commonly used to effect the above reactions: hydrated lime ($Ca(OH)_2$), calcined or quick lime (CaO), caustic soda ($NaOH$), or soda ash (Na_2CO_3). Selection of one of these alkaline compounds depends upon the acidity and ferrous/ferric iron ratio of the raw mine water, and the availability and cost of the reagents.

Hydrated Lime is the most commonly used reagent for pH adjustment. It can be introduced as an aqueous slurry or as a dry powder. The slurry can be prepared using the acid drainage, good quality water or treated effluent. Dry lime or lime slurry is then, in most cases, added to the acid mine drainage (AMD) in a mixing tank. Addition rates can be controlled automatically or manually.

Calcined Lime (also termed "unslaked" or "quicklime") can also be used as a reagent. A potential problem with the use of either calcined lime or hydrated lime is the formation of gypsum ($CaSO_4$ $2H_2O$). This compound forms when calcium ions from the lime reagent combine with the typically high concentrations of sulfate ions present in AMD. Gypsum will deposit on tanks, impellers, piping, control equipment including pH probes, and other surfaces that contact the treated AMD. High concentrations of gypsum, if allowed to accumulate, may result in plugged lines and damaged equipment. This problem can be lessened with proper chemical dosages, and correctly sized pipes and tanks. The selection of the type of lime used is a matter of economics which usually favor hydrated lime except in very large installations, where use of unslaked lime becomes advantageous.

Caustic Soda or Sodium Hydroxide (NaOH) is used as the neutralization reagent in a number of acid mines; most of these have drainage with lesser acidity and iron concentrations, or low flows. Caustic soda is a strong base, but it is also the most expensive per unit of alkaline equivalence. As an aqueous solution, it mixes readily with AMD, and reacts rapidly.

The use of an aqueous solution of caustic soda may eliminate the need for expensive dispensing and mixing equipment. Savings in capital and operating costs of such a system may more than offset the additional expense of the reagent when only small amounts of alkali are needed. Where calcium is the limiting reactant, caustic soda does not precipitate calcium sulfate. This substantially decreases gypsum deposits.

Caustic soda use also has several disadvantages. The reagent is dangerous to handle, requiring the use of protective clothing. Although it is available in 50 percent solution, this solution freezes at 54° F and thus often requires heating to remove it from the transport containers. Thus, a 20 percent solution is favored where winter temperatures are below freezing. Nevertheless, even the 20 percent solution can continue to be difficult to pump at winter temperatures. Also, because sodium hydroxide is such a strong base, closer flow-proportioned control is required to prevent overtreatment (1).

Soda Ash or Sodium Carbonate (Na_2CO_3) is used as an alkaline reagent by a small perdentage of mining operations. Although some degree of caution must be exercised in the use of soda ash, the hazards associated with its handling are less than with caustic soda. Similar to lime, soda ash can be added dry (ground or in briquettes), or as a slurry. The sludge formed with soda ash settles to greater densities than sludge resulting from lime addition or caustic soda, but reagent consumption is also relatively high.

Limestone has the lowest cost of any of the neutralizing reagents. It is used minimally, however, because of several factors. Two predominant disadvantages are that limestone has very low reactivity at high pH and its use results in the formation of gypsum. This substance coats the unreacted limestone and further reduces its reactivity. The achievable pH ceiling for limestone treatment is approximately 7.5, which is insufficient to precipitate many metals (particularly manganese) (1).

The control effectiveness of neutralization and settling on metals is dependent upon the reagent used, influent and effluent pH, temperature, flow, and the presence of any side reactions including metal chelation and mixed-metal hydroxide complexing. Complete mixing of the alkaline agent and AMD is also important to control effluent pH and metals removal. Table VII-1 presents metals removal data for lime neutralization generated in a pilot plant treatment study at EPA's Crown Field site (2). Referring again to Figure VII-1, oxidation of iron from its ferrous to ferric state can be achieved using aeration.

Aeration

Often, aeration is accomplished by allowing the water to simply flow or cascade down a staircaselike trough or sluiceway. This causes turbulence that increases the oxygen transfer rate and therefore the oxidation reaction rate. In other cases, the air or oxygen may be supplied by one or more of the following types of aerators:

1. Diffused air systems,
2. Submerged turbine aerators
3. Surface aerators.

The oxidation system consists of a tank or pond fitted with one of the above aeration systems. The presence of dissolved oxygen supplied by the aerating technique oxidizes ferrous ions enhancing the formation of essentially insoluble ferric hydroxide. The resulting sludge is more easily settled. Temperature, pH, flow, dissolved oxygen content, and initial concentration are all important design parameters (3).

The control performance of aeration will cause a nearly complete conversion of influent ferrous ion to the oxidized or ferric state. Further, many volatile organics present are often stripped or oxidized

Table VII-1

TRACE ELEMENT REMOVAL BY LIME NEUTRALIZATION
- CROWN MINE PILOT PLANT STUDY -

Parameters	Spiked Influent	pH-7 mg/l	pH-9 mg/l	pH-11 mg/l
Arsenic	1.90 mg/l	.10	.04	.03
Boron	2.36	2.25	-	1.90
Cadmium	.90	.18	.08	.01
Chromium	.54	.04	.07	.05
Copper	5.30	.30	.11	.06
Mercury	.50	.02	.01	.02
Nickel	.66	.34	.08	.06
Phosphorous	9.83	3.81	2.30	3.56
Selenium	.94	.05	.16	.39
Zinc	5.65	1.01	.11	.11

Source: (2)

by this process to nondetectable levels (4). Referring again to Figure VII-1, the neutralized wastewater, laden with insoluble precipitates, is routed to a settling facility prior to final discharge.

Settling

The process of sedimentation removes the suspended solids, which includes the insoluble precipitates. Sedimentation can be accomplished in a settling pond or clarifier (a settling tank). The extent of solids removal depends upon surface area, retention time, flow patterns, settling characteristics of influent suspended solids, and other operating parameters of a particular installation. Clarifiers are mechanical settling devices which can be used where insufficient land exists for construction of a pond. Clarifiers operate on essentially the same principles as a sedimentation pond. The most significant advantage of a clarifier is that closer control of operating parameters such as retention time and sludge removal can be maintained, while problems such as runoff from precipitation and short-circuiting can be avoided.

Center feed (the most common), rectangular, and peripheral feed basins are a few of the several clarifier designs. Center feed clarifiers have four distinct sections: the inlet zone, the quiescent settling zone, the outlet zone, and the sludge zone. The inlet zone allows a smooth transition from the high velocities of the inlet pipe to the low uniform velocity needed in the settling zone. Careful control of the velocity change is necessary to avoid turbulence, short-circuiting, and carryover. The quiescent settling zone must be large enough to reduce the net upward water velocity to below the settling rate of the solids. The outlet zone provides a transition from the low-velocity settling zone to the relatively high overflow velocities. The sludge zone must effectively settle, compact, and collect the solids and remove this sludge without disturbing the settling zone above. The bottom of the circular clarifier is usually sloped five to eight degrees to the center of the unit where sludge is collected in a hopper for removal. Mechanically driven sludge rakes rotate continuously and scrape the sludge down the sloped bottom to the sludge hopper (see Figure VII-2).

The rectangular basin or clarifier is similar to a section of a center feed clarifier with the inlet at one end and the outlet at the other. Usually a flight system removes sludge in the rectangular basin. The flights travel along the basin bottom to convey the sludge to a discharge hopper. To avoid turbulence, which would hinder settling, the flight system moves slowly. This type of clarifier has the advantage that common walls can be used between multiple units to reduce construction costs (see Figure VII-3).

The peripheral feed or rim feed clarifiers shown in Figure VII-4, are designed to utilize the entire volume of the circular clarifier basin for sedimentation. In both types of clarifiers, water enters the lower section at the periphery at very low velocities to provide

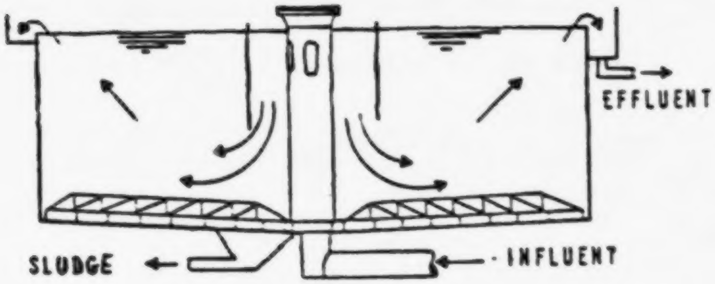


Figure VII-2

CIRCULAR CENTER FEED CLARIFIER WITH
A SCRAPER SLUDGE REMOVAL SYSTEM

Source: (5)

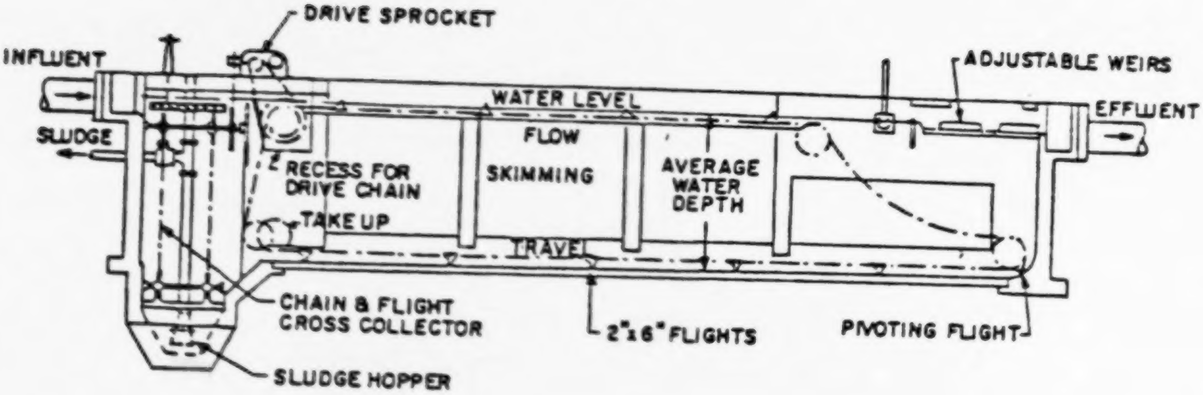
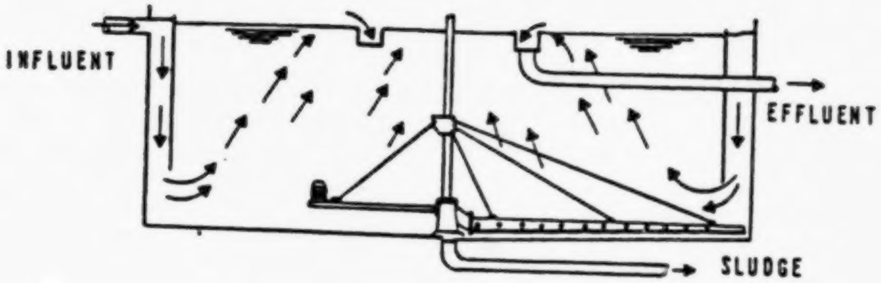


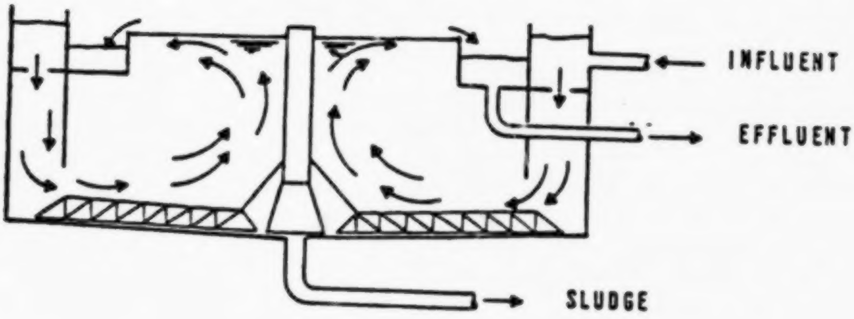
Figure VII-3

RECTANGULAR SEDIMENTATION CLARIFIER
WITH CHAIN AND FLIGHT COLLECTOR

Source: (5)



(a) CIRCULAR RIM-FEED, CENTER TAKE-OFF CLARIFIER WITH A HYDRAULIC SUCTION SLUDGE REMOVAL SYSTEM



(b) CIRCULAR RIM-FEED, RIM TAKE-OFF CLARIFIER

Figure VII-4

PERIPHERAL FEED CLARIFIERS

Source: (5)

immediate settling of large particles. In a peripheral take-off configuration, the flow then accelerates toward the center and subsequently drops as the flow reverses and redirects to a peripheral overflow weir. In the center take-off system, effluent is discharged through weirs located centrally. Peripheral feed clarifiers are sensitive to temperature changes and load fluctuations. Sludge recirculation is difficult with these types of clarifiers.

Clarification of acid mine drainage produces two secondary streams: the clear overflow or decant and the sludge underflow. The overflow is often discharged in current treatment systems. The dilute solids underflow stream, usually of only 5 to 10 percent solids content is often dewatered further before final disposal. Evaporation, centrifugation, and vacuum filtration are several techniques that may be used to further dewater sludges from clarifiers prior to ultimate disposal.

Installation of clarifiers to provide sedimentation is principally in hilly or mountainous areas where suitable land for a sedimentation pond is difficult to obtain. Ponds can also be installed to provide sedimentation capability. The settling pond can be created by excavating a depression or damming a natural runoff water course. For example, an abandoned strip mine pit at surface facilities may be used.

The purpose of a sediment basin is to remove sediment from runoff and thus protect drainageways, properties, and rights-of-way below the sediment basin from sedimentation (6). Construction of these basins is regulated primarily by the Office of Surface Mining Reclamation and Enforcement (OSM) in the Department of Interior. A settling pond operates on the principle that as the sediment laden water passes through the pond, the particles will settle to the bottom and be trapped. Some of the factors affecting the settling velocity of a particle include water viscosity (which is a sensitive function of temperature), and the density, size, and shape of the particle. For instance, as the temperature increases, the water viscosity decreases, and thus a particle will have a greater settling velocity in warm water (7, 8, 9, 10, 11, 12).

The use of sedimentation facilities has been commonplace in the industry for some time. Some mines, particularly in mountainous areas, may opt for several small ponds. These ponds are usually constructed in series, with the decant of one flowing into another. Other acid mine drainage treatment plants use two ponds in a parallel configuration. When the sludge content in one pond has reached capacity, flow is diverted to the second pond and the sludge in the first is either removed by dredging or allowed to undergo drying and compaction which greatly reduces the sludge volume. When the second pond is full of sludge, flow is returned to the first and the cycle is repeated. Application of the above treatment technologies to acid mine drainage will result in achievement of the BPT limitations discussed in Reference 13.

Candidate Treatment Technologies

Source control options are discussed under the best management practices subsection (Section X). The candidate end-of-pipe technologies examined for treatment of acid mine drainage were previously listed and include:

1. Flocculant Addition,
2. Granular Media Filtration,
3. Activated Carbon,
4. Ion Exchange,
5. Reverse Osmosis,
6. Electrodialysis,
7. Ozonation, and
8. Sulfide Precipitation.

The first two technologies were selected for further study. The remaining technologies and the reasons for their rejection are discussed below.

Activated Carbon

Activated carbon technology is predicated upon the considerable sorptive properties of granular or powdered carbon. The activated carbon process is often associated with organics removal, although some reduction of heavy metals can also be accomplished (14, 15).

A typical system is depicted in Figure VII-5. Contaminated water is introduced across a fixed or moving bed of granular or powdered activated carbon. Residence time in the bed is the major control parameter for pollutant removal. When a bed becomes fully loaded or exhausted, the adsorbent must be regenerated or disposed of. Regeneration (for granulated carbon only) is usually effected by heating to volatilize any organics and/or heavy metals. The adsorptive capacity of carbon depends on the pore size, typical size of the sorbed molecules, pH of the solution, temperature, and the initial pollutant concentration. Adsorption capacity generally increases as pH decreases and, normally, adsorption efficiency increases as the concentration increases (14).

A large amount of data is available on organic pollutant removal by this technology, whereas less data exist in the literature for metals removal. For cases where metals are present in the untreated wastewater at the parts per million level, significant reductions of Sb, As, hexavalent Cr, Sn, Ag, Hg, Pb, and Ni are documented in the literature (16). Cu, Cd, and Zn removals vary widely, while concentrations of Ba, Se, Mo, Mn, and W are not significantly reduced. BPT-treated effluents in the coal mining industry contain toxic metals at the parts per billion level, and data quantifying reductions beyond these levels are not available.

Table VII-2 presents an estimate of general effluent water quality parameters. Suspended solids will quickly foul an activated carbon

Table VII-2

ESTIMATED EFFLUENT CONTAMINANT LEVELS - ACTIVATED CARBON

	Acid Mines		Alkaline Mines	
	30-Day Average*	Daily Maximum*	30-Day Average*	Daily Maximum*
pH	6-9.00	6-9.00	6-9.00	6-9.00
Total iron	2.00	3.00	2.00	3.00
Dissolved iron	0.30	0.60	--	--
Manganses, total	2.00	4.00	--	--
Total suspended solids	15.00	30.00	15.00	30.00

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*All values in mg/l except pH.

Source: (15)

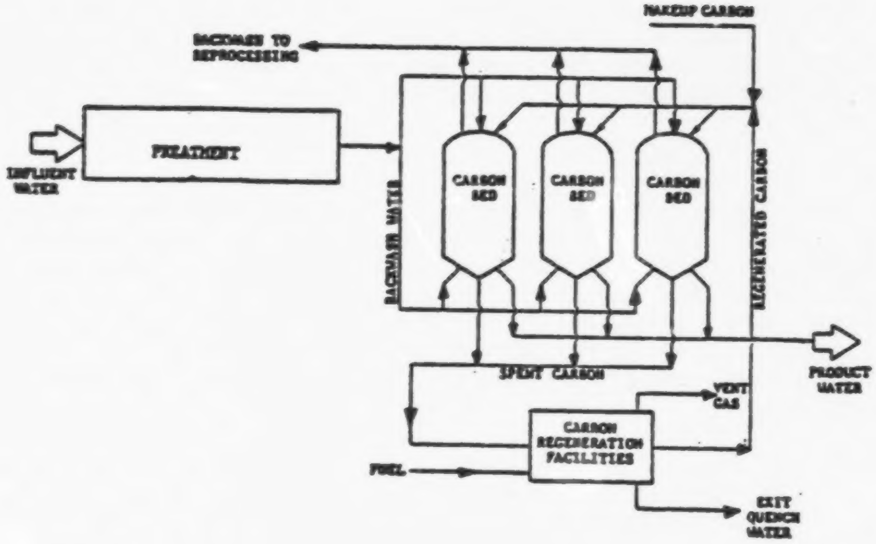

Figure VII-5
ACTIVATED CARBON SYSTEM

column, hence, filtration, which will itself reduce metals concentrations, is a required pretreatment step in an activated carbon system. Activated carbon columns would be very difficult to operate at remote sites. Some provision for regeneration (typically including multiple hearth furnaces) is required to make such a system cost effective. Beyond this, the substantial capital cost for equipment and the high operating costs for carbon purchase and regeneration cannot be justified for any potential additional reductions of metals beyond BPT. Based on these factors, activated carbon is not selected as a BAT option for further analysis.

Ion Exchange. The property of reversible interchange of ions between solids and liquids is the fundamental principle of ion exchange. Ion-rich water is introduced into an exchanger or column in which a solid resin bed resides. This resin, most commonly a type of styrenedivinylbenzene copolymer, has the ability to sorb (capture) and contain ions before release during regeneration. Of the many ion exchange configurations available, a typical arrangement, shown in Figure VII-6, is a cation column using an acidic solution for regeneration, followed by an anion column using an alkaline regeneration solution to elute (de-absorb with a solvent) sorbed anions.

Individual ion exchange systems do not generally exhibit equal affinity or capacity for each ionic species, and hence may not be suited for broad-spectrum removal schemes in wastewater treatment. Their behavior and performance are usually dependent upon pH, temperature, exchange resins, and concentration. The highest removal efficiencies are generally observed for polyvalent ions. In wastewater treatment, some pretreatment or preconditioning of wastes to adjust suspended solid concentrations and other parameters is likely to be necessary.

High concentrations of ions other than those to be recovered may interfere with practical removal. Calcium ions, for example, are generally collected along with the divalent heavy metal cations of copper, zinc, lead, etc. High calcium ion concentrations, therefore, may make ion exchange removal of divalent heavy metal ions impractical by causing rapid loading of resins.

Ion exchange can effectively produce low levels of metals. However, although ion exchange is a commercially available technology, it becomes uneconomical on streams high in dissolved solids due to resin replacement costs. Even at less than 500 ppm dissolved solids, ion exchange is expensive and requires relatively sophisticated equipment and control (2, 3, 17). Table VII-3 presents data from an EPA mine drainage study showing metals removal (2).

A number of operational disadvantages are associated with this technology. For instance, secondary pollution stream is generated and must be treated. Iron fouling is a common problem in the cation sorption column, necessitating an acidification step prior to the first resin bed. Also, a final effluent neutralization step is

Table VII-3

ION EXCHANGE EFFLUENT WATER QUALITY (in mg/1)

Parameter	Spiked Feed (mean)	Cation Effluent (mean)	Anion Effluent (mean)
pH	4.8	1.9	9.9
Arsenic	2.47	1.68	0.52
Cadmium	0.95	0.04	0.001
Chromium	0.63	0.05	0.01
Copper	7.27	0.11	0.03
Iron, total	160	2.1	0.05
Manganese	3.9	0.09	0.05
Mercury	0.72	0.07	0.001
Nickel	0.86	0.02	0.02
Selenium	1.34	1.19	0.09
Zinc	7.44	0.14	0.03

Source: Adapted from (2)

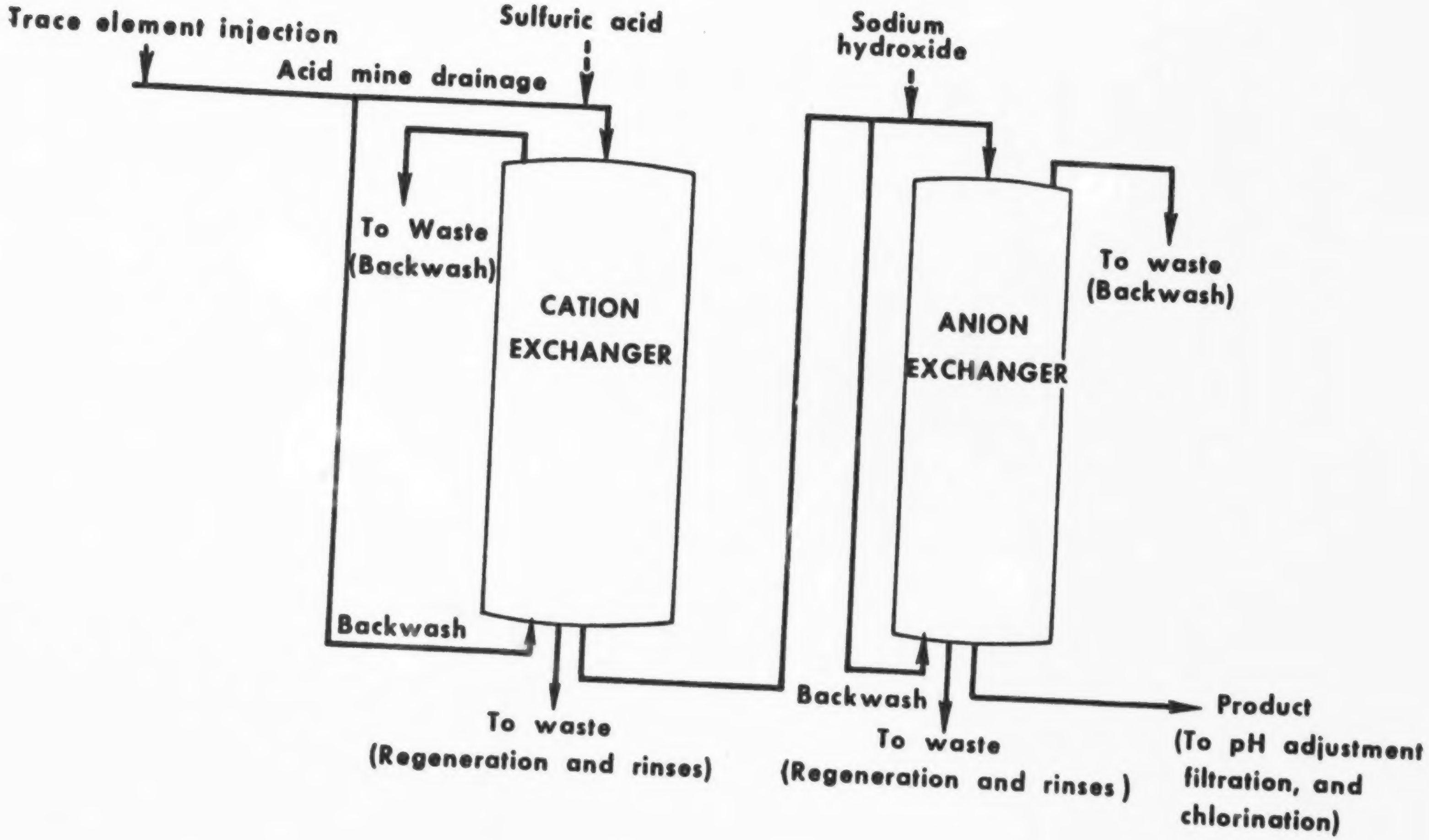

Figure VII-6

CONCEPTUAL DESIGN OF AN ION EXCHANGE SYSTEM

Source: (2)

required if the pH remains too high downstream of the anion exchanger. Acidic and basic regenerant solutions are required. Operation of this relatively sophisticated system at remote sites, especially in the mountainous terrain of Appalachia, would be very difficult. For these reasons, this technology was not selected as a BAT option for further analysis.

Reverse Osmosis

Reverse osmosis is the process of concentrating ions on one side of a semipermeable membrane by the application of external pressure. This pressure must be sufficient to overcome the osmotic gradient which acts in the opposite direction--hence, the name reverse osmosis. This is schematically illustrated in Figure VII-7. Water is separated from the ions by forcing it across a membrane, which is impervious to ion transfer. Treated water is then decanted and discharged, while the brine requires further treatment prior to disposal.

Since 1966, the EPA has been sponsoring and conducting research to determine the potential of using reverse osmosis to treat acid mine drainage. This EPA work includes pilot plant studies that have been undertaken at the Crown Mine Drainage Control Field Site (2). Results from these and other research efforts (19) have shown that in treating mine drainage, reverse osmosis can remove nearly all dissolved solids and up to 95 percent of the aluminum, iron, calcium, magnesium, manganese, sodium, and sulfate ions.

The basic reverse osmosis system consists of a number of potential pretreatment steps (e.g., filtration, pH adjustment); a high pressure pump (400 to 800 psig); a reverse osmosis membrane package; and post-treatment, if necessary (Figure VII-8). One of the problems encountered in applying reverse osmosis to acid mine drainage treatment is fouling of the membranes. Fouling of a semipermeable membrane is defined as any reduction in permeability or efficiency due to blinding of the membrane by suspended solids, age of the membrane, or deterioration of the membrane. Membrane fouling progressively lowers water recovery (until recovery rates are no longer practical).

The two major causes of fouling in the treatment of acid mine drainage are chemical and bacterial. Two solutions for the bacterial fouling are to disinfect the water before it enters the reverse osmosis unit or to adjust the mine water to below pH 2.5 which greatly retards bacterial growth. The two chief chemical compounds that can foul the membrane are the sulfates of iron and calcium. Under normal conditions ferric iron fouling can be controlled either by the addition of an acid to maintain a pH below 3.0 or by the addition of reducing chemicals such as sodium sulfite, to reduce ferric iron to ferrous. The stream can also be filtered prior to polishing in a reverse osmosis unit to remove suspended material such as ferric or calcium sulfate.

Table VII-4 presents effluent pollutant reductions of acid mine drainage achievable by reverse osmosis. Although reverse osmosis is

Table VII-4

EFFLUENT WATER QUALITY ACHIEVED BY REVERSE OSMOSIS (in mg/l)

Parameter	Spiked Feed (mean)	Product (mean)	Brine (mean)
pH	2.2	2.0	3.6
Arsenic	2.29	0.01	3.58
Cadmium	0.83	0.006	1.22
Chromium	0.54	0.01	0.82
Copper	6.18	0.01	9.12
Iron, total	170	0.30	270
Manganese	110	0.20	180
Mercury	0.28	0.06	0.17
Nickel	0.74	0.01	1.10
Selenium	1.17	0.11	1.83
Zinc	6.25	0.06	9.63

Source: Adapted from (2)

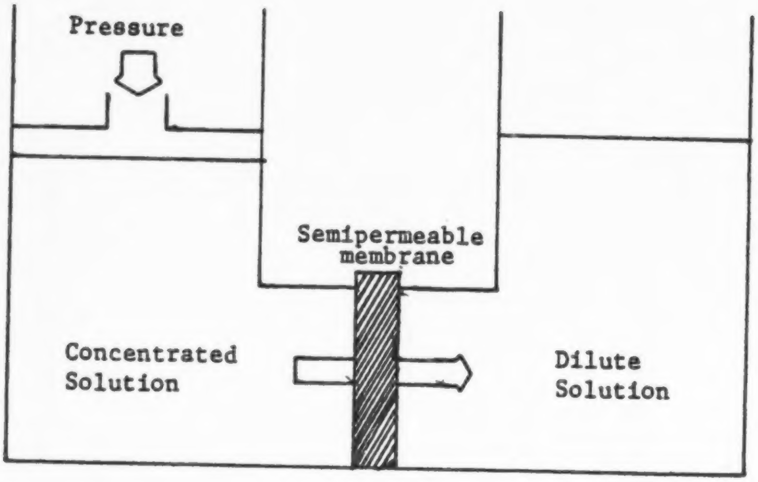

Figure VII-7

TRANSFER AGAINST OSMOTIC GRADIENT IN REVERSE OSMOSIS SYSTEM

Source: Adapted from (18)

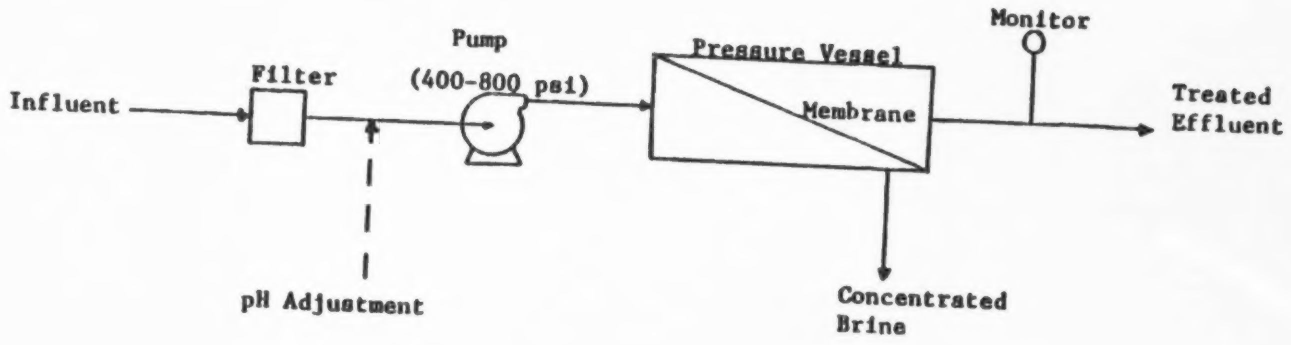

Figure VII-8

SCHEMATIC OF REVERSE OSMOSIS SYSTEM

Source: Adapted from (18)

slightly more effective than lime neutralization and settling for metals removals, this technology is very expensive and appropriate only for low volume, high dissolved solids feed streams. Further, concentrated brine requiring further treatment is generated from the separation chambers.

Based on the above considerations, reverse osmosis was not selected as a BAT option for further analysis.

Electrodialysis

Electrodialysis can be used for the control of dissolved inorganics in coal mine wastewaters. The technology is based upon differentially permeable membranes operating in an electric field. Contaminated water is introduced into a cell or "stack" of alternating anion- and cation-permeable membranes. With an electric field applied across the stack providing the driving force, ions are forced into alternating cells, while deionized water is withdrawn from the remaining cells (Figure VII-9). A small bench-scale electrodialysis unit was tested by the Federal Water Pollution Control Administration at its Mine Drainage Treatment Laboratory, Norton, West Virginia, in cooperation with the Office of Saline Water (17). When used on drainage without pretreatment, the cathode cell quickly became fouled with iron. In those cases where the mine drainage was pretreated by lime neutralization for iron removal, the unit operated satisfactorily. Electrodialysis is a costly technology suitable chiefly for low flow, high dissolved solids streams, with pretreatment frequently necessary. Energy requirements to maintain the electrical field add significantly to the operating costs. The process also produces a secondary stream of concentrated brine that requires further treatment. Based on the above considerations, electrodialysis was not selected as a BAT option for further analysis.

Ozonation

Ozone, O_3, is an unstable molecule that is a powerful oxidant. Its primary application to the coal mining industry is oxidation of metal compounds that render them less soluble and thus increases the settling rates. It has also been shown to be effective in the oxidation of soluble manganese to an insoluble state which can be removed prior to discharge into streams. Because of the instability of ozone, facilities for on-site generation are required. The gas is generated by passing air across a high voltage field (5 to 30 kilovolts). The gas is then injected into a stream where oxidation occurs (3). Preliminary cost estimates show ozonation to be a relatively costly technology. Further, no data are available to quantify toxic metals removal by ozonation systems on coal mine drainage.

Finally, suspended solids in substantial concentrations impede ozonation performance (16). Because of these factors, ozonation was not selected as a BAT option.

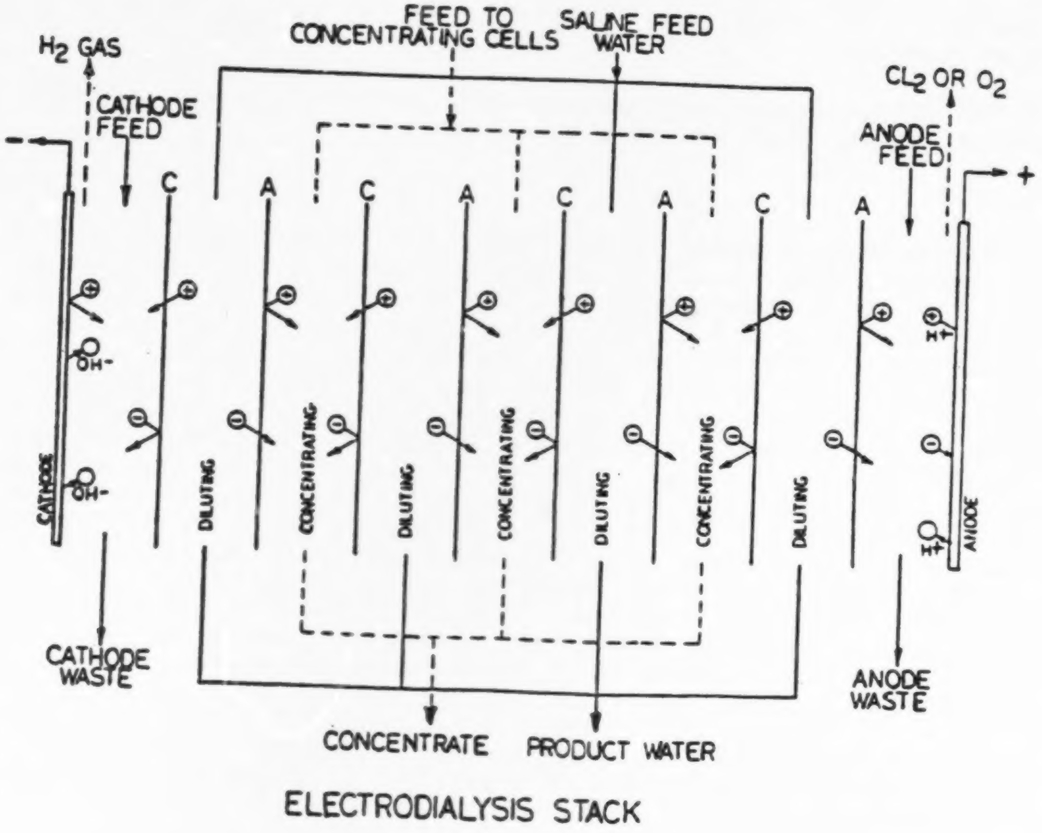

Figure VII-9
CONFIGURATION OF ELECTRODIALYSIS CELLS

Source: (17)

Sulfide Precipitation

Sulfide precipitation is analogous to lime precipitation in that heavy metal cations (positively charged) are combined with anions (negatively charged) to form an insoluble compound that settles out of solution. In this process, sulfide is the anion used. Sulfide precipitates vary in solubility which will determine the removal efficiency. Heavy metal sulfides are in general very insoluble and have excellent settling properties. Table VII-5 gives the theoretical solubilities of hydroxides and sulfides of various metals in pure water. In addition to having lower solubilities than hydroxides in the alkaline pH ranges, sulfides also tend to have low solubilities in the pH 7 range or below (14). Several steps enter into the process of sulfide precipitation (16): 1. Preparation of sodium sulfide. Although this product is often in oversupply from byproduct sources, it can also be made by reduction of sodium sulfate. The process involves an energy loss in the partial oxidation of carbon (such as that contained in coal) as follows:

$$Na_2SO_4 + 4C \longrightarrow Na_2S + 4CO \text{ (gas)}$$

2. Precipitation of the pollutant metal (M) in the waste stream by an excess of sodium sulfide:

$$Na_2S + MSO_4 \longrightarrow MS \text{ (precipitate)} + Na_2SO_4$$

3. Physical separation of the metal sulfide in thickeners or clarifiers, with reducing conditions maintained by excess sulfide ion.

4. Oxidation of excess sulfide by aeration:

$$Na_2S + 2O_2 \longrightarrow Na_2SO_4$$

In practice, sulfide precipitation can be best applied when the pH is sufficiently high (greater than eight) to assure generation of sulfide, rather than bisulfide ion or hydrogen sulfide gas. A process utilizing ferrous sulfide as the principal source of sulfide ion has been developed and appears to overcome the problem from the FeS only when other heavy metals with lower equilibrium constants for their sulfide form are present in solution. If the pH can be maintained at 8.5 to 9, the liberated iron will form a hydroxide and precipitate out as well.

Although very effective in pollutant removal, sludge produced from sulfide precipitation is easily degraded to soluble salts that will leach toxic materials. Sludge produced from lime addition is much more stable (15). The most probable application of sulfide technology is as a polishing unit downstream of a lime precipitation unit. However, to be implemented in the coal industry, the problem of potential leaching of soluble salts from sulfide precipitation sludge must be mitigated or circumvented. Also, the cost of operation with sulfides is much higher than lime neutralization, with only slight improvement in effluent quality. These factors preclude sulfide

Table VII-5

THEORETICAL SOLUBILITIES OF HYDROXIDES AND SULFIDES OF HEAVY METALS IN PURE WATER

Metal	Solubility of Metal Ion (mg/l)	
	As Hydroxide	As Sulfide
Cadmium (Cd++)	2.3×10^{-5}	6.7×10^{-10}
Chromium (Cr+++)	8.4×10^{-4}	No precipitate
Cobalt (Co++)	2.2×10^{-1}	1.0×10^{-8}
Copper (Cu++)	2.2×10^{-2}	5.8×10^{-18}
Iron (Fe++)	8.9×10^{-1}	3.4×10^{-5}
Lead (Pb++)	2.1	3.8×10^{-9}
Manganese (Mn++)	1.2	2.1×10^{-3}
Mercury (Hg++)	3.9×10^{-4}	9.0×10^{-20}
Nickel (Ni++)	6.9×10^{-3}	6.9×10^{-8}
Silver (Ag+)	13.3	7.4×10^{-12}
Tin (Sn++)	1.1×10^{-4}	3.8×10^{-8}
Zinc (Zn++)	1.1	2.3×10^{-7}

Sources: (20, 21, 22)

precipitation from being considered as a candidate best available technology.

The two technologies recommended for further evaluation and economic impact assessments are flocculant addition and granular media filtration. These are discussed in the following paragraphs.

Flocculant Addition

Flocculant addition is a term often used interchangeably with chemical coagulation. The process involves the aggregation and settling of suspended particles by the addition of a coagulant aid. Technically, coagulation involves the reduction of electrostatic surface charges and the initial formation of aggregated material. Coagulation is essentially instantaneous in that the only time required is that time necessary for dispersing the chemicals in solution. Flocculation is the time dependent physical process of the aggregation of wastewater solids into particles large enough to be separated by sedimentation, flotation, or filtration.

For particles in the colloidal and fine supracolloidal size ranges (less than one to two micrometers), natural stabilizing forces (electrostatic repulsion, physical repulsion by absorbed surface water layers) predominate over the natural aggregating forces (van der Waals) and the natural mechanism which tends to cause particle contact (Brownian motion). The function of chemical coagulation of wastewater may be the removal of suspended solids by destabilization of colloids to increase settling velocity, or the removal of soluble metals by chemical precipitation or adsorption on a chemical floc (16).

There are three different types of flocculants: inorganic electrolytes, natural organic polymers and synthetic organic polyelectrolytes. Inorganic electrolytes are salts or multivalent ions such as alum (aluminum sulfate) that act by neutralizing the charged double layer of colloidal particles. Natural organic polymers are derived from starch, vegetable materials, or monogalactose, and act to agglomerate colloidal particles through hydrogen bonding and electrostatic forces. Synthetic polyelectrolytes are polymers that incorporate ionic or other functional groups along the carbon chain in the molecule. The functional groups can be either anionic (attract positively charged species), neutral or cationic (attract negatively charged species). Polyelectrolytes function by electrostatic bonding and the formation of physical bridges between particles, thereby causing them to agglomerate.

The colloidal particles in AMD sludge usually carry a negative charge. Consequently a cationic flocculant must be used. Synthetic polyelectrolytes are most frequently employed since they function best in the high ionic strength solutions encountered in AMD.

Chemical coagulants are most commonly added upstream of sedimentation ponds, clarifiers, or filter units to increase the efficiency of solids separation. The settling solids are more effective in adsorbing fine metal hydroxide precipitates. As these fine particles are agglomerated and settled, equilibrium relationships will cause additional dissolved metals to react and form additional insoluble precipitates. The major disadvantage of the addition of certain coagulants to a raw wastewater stream is the production of large quantities of sludge, which must subsequantly be disposed of. Therefore, raw wastewaters may be treated by removal of easily settled particles in a primary sedimentation pond. Coagulants are then added to this effluent prior to secondary settling or filtration. In most cases, chemical coagulation can be used with minor modifications and additions to existing treatment systems. In mines with acid drainage, this would be accomplished by polymer addition downstream of neutralization and primary settling facilities.

To assist in determination of performance characteristics of this technology at acid mines, a treatability study (23), was performed at four coal mine sites exhibiting acid mine drainage. Raw acid mine drainage samples (from the Crown, Norton, Hollywood, and Will Scarlet sites) were treated via lime neutralization and precipitation, flocculation, aeration and settling.

Chemical dosage rates and polymer selection were determined by jar tests. Settling tests were then conducted in an eight-inch inner diameter by eight foot high settling tube to establish performance data. Spiking solutions containing priority metals were added to the acid mine drainage to raise influent concentrations to levels significant for measurement of test parameters. The chief objective of the study was to establish priority metals and suspended solids concentrations achievable by application of chemically aided precipitation.

Settling tests performed with dosages of each chemical are summarized in Table VII-6. Influent suspended solids concentrations are recorded after addition of lime. As can be seen from Table VII-6, flocculant addition consistently reduces effluent suspended solids to 20 mg/l or less. In fact, reductions below 10 mg/l are frequent. Also, in other industries, such as ore mining, reductions via flocculant addition of total suspended solids to 15 mg/l and less are typical.

The removal of priority metals was also evaluated for each of the 28 settling tests. Because spiking solutions were not readily obtainable and background levels were less than the detection limits, no data could be recorded for removals of arsenic, antimony, selenium, and thallium. Referring to Table VII-7, consistently high removals were achieved for beryllium, cadmium, chromium, copper, iron, mercury, nickel, lead, and zinc. Less consistent reduction is achieved for silver and manganese. These effluent levels are summarized in Table VII-7.

A number of points concerning this table should be made. First, raw mine drainage from these facilities does not exhibit high (>1.0 mg/l) concentrations of priority metals. Copper, lead, zinc, chromium (hexavalent), mercury, nickel, cadmium, and manganese were thus added

Table VII-6

SUMMARY OF SETTLING TESTS PERFORMED

WITH FLOCCULANT ADDITION

Mine	Test No.	Spiked	Chemicals Added			Initial pH	Final pH	Suspended Solids (mg/l)	
			Lime (mg/l)	Sodium Sulfide (mg/l)	Polymer (mg/l)			Influent	Effluent
Crown	C-1		0	0	0	5.0	5.0	15.95	17.8
	C-2	x	0	0	0	4.9	4.9	11.6	14.4
	C-3		350	0	4[a]	-	7.1	466	19.0
	C-4	x	350	0	4[a]	-	7.0	414	15.8
	C-5		420	0	1[a]	-	7.7	434	3.4
	C-6	x	425	0	2[a]	-	7.8	535	2.0
Norton[d]	N-1		0	0	0	2.8	2.8	3.9	3.0
	N-2		300	0	2.0[a]	2.8	9.4	448	4.4
	N-3	x	290	0	2.0[a]	2.9	6.4	230	5.8
	N-4		275	0	0.5[b]	2.8	8.2	199	6.4
	N-5		270	0	1.0[b]	2.8	8.1	222	8.6
	N-6	x	300	0	1.0[b]	2.9	8.1	217	8.2
Hollywood[d]	H-1		250	0	2.0[a]	3.5	7.2	368	7.6
	H-2	x	265	0	1.0[a]	3.6	8.8	348	9.0
	H-3		225	0	1.0[a]	3.7	8.4	388	8.0
	H-4	x	250	0	1.0[b]	3.7	7.5	292	8.5
	H-5		260	0	1.0[c]	3.6	9.5	322	4.0
	H-6	x	340	0	1.0[c]	3.8	9.6	404	4.2
	H-7		275	80	1.0[c]	3.8	9.2	412	3.8
	H-8	x	360	130	1.0[c]	3.6	9.7	520	1.3
	H-9		300	0	1.0[c]	3.7	9.6	360	1.8
	H-10	x	445	0	1.0[c]	3.7	10.1	484	2.0
Will Scarlet[d]	S-1		10,400	0	1.0[c]	2.5	9.7	23,390	20.6
	S-2	x	17,325	0	1.0[c]	2.6	10.0	63,220	9.2
	S-3		7,660	0	2.0[c]	2.5	8.2	22,950	e
	S-4	x	20,000	0	4.0[c]	2.4	11.0	42,400	e
	S-5		15,220	0	2.0[c]	2.6	9.6	24,850	e
	S-6	x	11,870	670	2.0[c]	2.6	9.9	29,400	e

Notes:

[a] Dowell 144
[b] Dowell 905N
[c] Magnifloc 1820A
[d] All tests include 30 minute aeration of sample.
[e] Sludge was sampled from tap so no meaningful value could be recorded.

Source: (23)

Table VII-7

SUMMARY OF TEST RESULTS FOR METALS REMOVAL (mg/1) BY BPT AND FLOCCULANT ADDITION

Mine	Test No.	Effluent pH	TDS	Ag	As	Be	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	Zn
Crown	C-1 (Raw)																	
	Influent	4.9	3140	DL	DL	.008	.038	.047	.019	155	DL	4.6	.26	.002	DL	DL	DL	.400
	Effluent	5.0	3360	DL	DL	.007	.033	.042	.019	161	DL	4.7	.25	.008	DL	DL	DL	.400
	C-2 (spiked)																	
	Influent	4.9	3510	.011	DL	.007	.150	.086	.111	155	.80	4.7	.31	.280	DL	DL	DL	.470
	Effluent	4.7	3440	.007	DL	.007	.141	.085	.105	142	.126	4.3	.29	.294	DL	DL	DL	.430
	C-3																	
	Influent	7.0	3520	DL	DL	.008	.040	.038	.006	154	DL	4.5	.30	DL	DL	DL	DL	.390
	Effluent	7.2	3490	.019	DL	DL	.021	.041	.008	13	DL	2.9	.12	DL	DL	DL	DL	.008
	C-4 (spiked)																	
	Influent	7.0	3500	.006	DL	.007	.130	.089	.088	122	.003	3.9	.31	.340	DL	DL	DL	.390
	Effluent	7.0	3370	.016	DL	DL	.060	.047	.009	23	.032	3.4	.18	DL	DL	DL	DL	.031
	C-5																	
	Influent	7.7	3460	.015	DL	.007	.038	.058	.016	138	DL	4.2	.28	.002	DL	DL	DL	.378
	Effluent	7.7	3410	.015	DL	DL	.020	.047	DL	1.5	DL	1.9	.13	DL	DL	DL	DL	.442
	C-6 (spiked)																	
	Influent	7.8	3610	.012	DL	.006	.142	.090	.094	138	.170	4.2	.32	.200	DL	DL	DL	.410
	Effluent	7.8	3400	.008	DL	DL	.024	.046	.010	.82	.024	1.9	.11	DL	DL	DL	DL	DL
	Detection Limits	---	---	.005	.005	.001	.001	.002	.005	.005	.001	.005	.005	.001	.005	.010	.002	.002

Table VII-7 (Continued)

SUMMARY OF TEST RESULTS FOR METALS REMOVAL (mg/1) BY BPT AND FLOCCULANT ADDITION

Mine	Test No.	Effluent pH	TDS	Ag	As	Be	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	Zn
Norton	N-1 (Raw)																	
	Influent	2.8	997	.013	DL	.007	.237	.227	.411	40.3	.072	2.43	4.86	.004	DL	DL	DL	.888
	Effluent	2.8	951	DL	DL	.007	.006	.017	.876	41.8	.080	2.19	.275	DL	DL	DL	DL	.610
	N-2																	
	Influent	9.4	979	.005	DL	.008	.007	.020	.142	37.8	DL	2.31	.294	DL	DL	DL	DL	.617
	Effluent	9.4	993	DL	DL	DL	.056	.062	.066	.756	DL	.006	.058	DL	DL	DL	DL	.065
	N-3 (spiked)																	
	Influent	6.3	1100	.023	DL	.009	2.50	2.54	3.20	40.4	.790	4.73	2.78	7.0	DL	DL	DL	3.43
	Effluent	6.3	1100	DL	DL	DL	.686	.077	.084	1.03	.410	3.47	.960	.029	DL	DL	DL	.167
	N-4 (spiked)																	
	Influent	8.3	983	.013	DL	.009	.015	.023	.146	36.4	.655	2.33	.317	.002	DL	DL	DL	.641
	Effluent	8.1	1000	DL	DL	DL	DL	.008	DL	1.38	DL	.500	.066	DL	DL	DL	DL	.012
	N-5																	
	Influent	8.2	1020	.009	DL	.011	.009	.023	.242	54.4	.615	2.82	.358	DL	DL	DL	DL	.780
	Effluent	8.0	989	.006	DL	DL	.020	.013	.005	1.94	.110	.439	.080	DL	DL	DL	DL	.025
	N-6 (spiked)																	
	Influent	8.1	1140	.015	DL	.009	2.93	2.99	3.74	37.4	.750	5.23	3.18	8.5	DL	DL	DL	3.99
	Effluent	8.0	1090	.010	DL	DL	.210	.091	.093	.821	.625	2.12	.312	.037	DL	DL	DL	.095
	Detection Limits	---	---	.005	.005	.001	.005	.005	.005	.005	.001	.005	.005	.001	.005	.010	.002	.002

Table VII-7 (Continued)

SUMMARY OF TEST RESULTS FOR METALS REMOVAL (mg/1) BY BPT AND FLOCCULANT ADDITION

Mine	Test No.	Effluent pH	TDS	Ag	As	Be	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	Zn
Holly-wood	Raw	3.5	775	.022	DL	.006	.020	.040	.019	46.9	DL	1.33	.376	.010	DL	DL	DL	.521
	H-1																	
	Influent	7.0	881	.009	DL	.008	.022	.057	.033	58.0	DL	1.60	.481	DL	DL	DL	DL	.668
	Effluent	7.4	839	.008	DL	DL	.006	.017	.017	1.13	DL	.161	.072	DL	DL	DL	DL	.027
	H-2 (spiked)																	
	Influent	8.7	719	.011	DL	.006	3.01	2.66	2.79	33.3	1.20	34	3.38	4.8	DL	DL	DL	2.78
	Effluent	8.8	733	.020	DL	DL	.084	.089	.082	.803	.234	.179	.14	.040	DL	DL	DL	.076
	H-3																	
	Influent	8.4	637	.008	DL	.004	.014	.033	.023	38.2	DL	1.15	.305	DL	DL	DL	DL	.430
	Effluent	8.5	636	DL	DL	DL	DL	.019	DL	1.29	DL	.120	.074	DL	DL	DL	DL	.018
	H-4 (spiked)																	
	Influent	7.5	829	.010	DL	.008	3.16	2.82	2.93	39.4	DL	3.59	3.60	4.70	DL	DL	DL	2.99
	Effluent	7.6	891	.013	DL	DL	.220	.118	.105	1.29	.005	1.35	.414	.046	DL	DL	DL	.106
	H-5																	
	Influent	9.5	799	.011	DL	.008	.018	.039	.016	57.2	DL	1.59	.437	DL	DL	DL	DL	.625
	Effluent	9.5	822	.014	DL	DL	DL	.021	.006	.785	DL	.040	.079	DL	DL	DL	DL	.020
	H-6 (spiked)																	
	Influent	9.6	1060	.024	DL	.009	3.15	2.81	2.90	47.0	1.07	3.84	3.65	4.2	DL	DL	DL	3.04
	Effluent	9.6	1000	DL	DL	DL	.029	.048	.023	.351	.151	.060	.118	.015	DL	DL	DL	.017
	H-7																	
	Influent	9.2	846	DL	DL	.009	.019	.043	.015	50.1	DL	1.42	.409	DL	DL	DL	DL	.565
	Effluent	9.2	864	DL	DL	DL	DL	.017	DL	.534	DL	.026	.075	DL	DL	DL	DL	.017
	H-8 (spiked)																	
	Influent	9.6	980	.006	DL	.009	3.11	2.83	2.90	51.1	.715	3.95	3.67	4.50	DL	DL	DL	3.07
	Effluent	9.7	1000	DL	DL	DL	.024	.047	.022	.395	DL	.041	.109	.011	DL	DL	DL	.023
	H-9																	
	Influent	9.7	879	.017	DL	.004	.015	.042	.015	48.9	DL	1.40	.401	DL	DL	DL	DL	.558
	Effluent	9.4	831	.013	DL	DL	DL	.019	DL	.477	DL	.027	.085	DL	DL	DL	DL	.008
	H-10 (spiked)																	
	Influent	10.2	1090	.022	DL	.005	2.93	2.72	2.79	45.9	2.82	3.74	3.56	5.5	DL	DL	DL	2.92
	Effluent	10.0	1030	.014	DL	DL	.024	.043	.026	.306	.819	.032	.104	.008	DL	DL	DL	.017
	Detection Limits	---	---	.005	.001	.001	.002	.005	.001	.005	.005	.005	.005	.001	.005	.010	.002	.002

Table VII-7 (Continued)

SUMMARY OF TEST RESULTS FOR METALS REMOVAL (mg/1) BY BPT AND FLOCCULANT ADDITION

Mine	Test No.	Effluent pH	TDS	Ag	As	Be	Cd	Cr	Cu	Fe	Hg	Mn	Ni	Pb	Sb	Se	Tl	Zn
Will Scarlet	Raw	2.03	19100	.241	DL	.175	.603	.461	.246	10.50	.628	183	7.27	.012	DL	DL	DL	31.6
	S-1																	
	Influent	9.6	2650	.168	DL	.137	.523	.431	.208	1220	DL	221	6.08	DL	DL	DL	DL	22.6
	Effluent	9.75	2920	.085	DL	.045	.196	.178	.081	311	DL	61.8	2.36	DL	DL	DL	DL	8.66
	S-2 (spiked)																	
	Influent	10.5	3250	.258	.017	.272	4.31	3.73	3.49	1980	.121	11.9	4.15	DL	DL	DL	DL	39.3
	Effluent	9.8	2610	.158	DL	DL	.051	.097	.082	.809	.013	.283	DL	DL	DL	DL	DL	.059
Detection Limits		---	---	.005	.005	.001	.001	.002	.005	.005	.001	.005	.005	.001	.005	.010	.002	.002

to the raw drainage in about half of the tests to yield a concentration of 3 mg/l for each of the metals prior to neutralization and flocculant addition. Due to an inadvertent error, the spiked solutions used at the Crown site produced an initial concentration of only 0.3 mg/l for each spiked priority metal. At Norton, these compounds were added as nitrates and at Hollywood, chloride metal salts were utilized.

Second, the quantity of lime required to neutralize the acidity in the drainage from Will Scarlet was so voluminous for tests S-3 through S-6 that the settled sludge kept the lower sampling tap (where metal samples were obtained) covered throughout the test. Thus, analytical results are available on the metals contained in AMD sludge, but are of no value and, as such, are not included on Table VII-7.

Thirdly, raw water characteristics from the Crown site are presented as settling tests C-1 and C-2. This is also true of the Norton site where test N-1 summarizes raw mine water settling characteristics. These tests were run without chemical addition to establish baseline performance data. Tests on raw water at Hollywood and Will Scarlett would be redundant and hence were not conducted.

Excluding the data from tests S-3 through S-6, means are presented in Table VII-8 for each of the final effluent metals concentrations (quantifying non-detected values as 1/2 the detection limit). These values represent achievable effluent limitations for acid mine drainage from deep and surface facilities through the application of BPT and flocculant addition technology.

Additional treatability analyses have been conducted by the Agency at the Crown, West Virginia site for polymer addition; results indicate that certain priority metals (Ni, Cu, Cr, and Se) are effectively reduced (2). Other studies have also confirmed the suspended solids and metals reductions documented above (16, 24, 25, 26, 27, 28).

In cases where settling ponds are at remote locations, construction of access roads and power lines will be necessary to install and maintain polymer feed equipment. The installation of chemical handling equipment, tanks, access roads, land, and power lines in remote areas could exacerbate coal mining production problems, particularly for small mines. Costs for those items are presented in the next section of this report. In some cases where ponds are difficult to access or lack electricity, gravity feed systems (used in one Western coal mine visited) or diesel generators can be employed.

Filtration

Filtration is used as a suspended solids and metals removal technology. Filter systems are usually located downstream of primary gravity settlers, lime precipitation units, or polymer addition equipment. Filtration is accomplished by the passage of water through a physically restrictive medium with resulting entrapment of suspended

Table VII-8

MEAN FINAL EFFLUENT CONCENTRATIONS (mg/l) FOR UNSPIKED AND SPIKED SAMPLES

	Unspiked		Spiked	
Metal	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**
Ag	.009	.006	.023	.045
As	.0025	0	.0025	0
Be	.0005	0	.001	.002
Cd	.0252	.060	.150	.203
Cr	.0581	.0622	.072	.0263
Cu	.0114	.0197	.0636	.043
Fe	2.28	3.79	2.96	7.04
Hg	0.0114	0.0327	.183	.280
Mn	.612	.986	1.55	1.60
Ni	.084	.023	.273	.263
Pb	.0005	0	.019	.018
Sb	.0025	0	.0025	0
Se	.005	0	.001	0
Tl	.001	0	.001	0
Zn	.0642	.134	.059	.0521

particulate matter. Filtration is a versatile method in that it can be used to remove a wide range of suspended particle sizes.

Filtration processes can be placed in two general categories: (1) surface filtration devices, including microscreens and diatomaceous-earth filters; and (2) granular-media filtration, such as rapid sand filters, slow sand filters, and multimedia filters. For application to coal mine wastewaters, granular media filtration systems are most suitable.

Granular media filtration utilizes a variety of mechanisms including straining, interception, impaction, and adsorption for suspended solids removal. Filters are most often classified by flow direction and type of filter bed. Downflow, multimedia filters would probably find the widest application to both acid and alkaline coal mine wastewaters. In such a system, influent is piped to the top of the filter and by gravity or external pressure percolates through the bed before discharge or further treatment.

Maximum loading of the filter is determined either by a prescribed permissible head loss (the pressure drop across the filter) or a ceiling level of suspended solids in the filtered effluent. When these conditions occur, the filter is backwashed and air-scrubbed to clean the bed, and the wash water disposed of in an acceptable manner, usually by settling and return to the head of the treatment plant.

Various combinations of media, including sand, gravel, garnet, activated carbon, anthracite coal, and ilmenite, can be used in a filtration system. These materials represent a wide distribution of specific gravities and grain sizes. Total media depths typically range from 50 cm to 250 cm, with feedwater flux rates of 2 to 30 gallons per minute per square foot of cross-sectional area, with 10 gpm per square foot typical.

Whenever possible, designs should be based on pilot filtration studies of the actual wastewater. Such studies are the best way to assure: (1) representative cost comparisons between different filter designs capable of equivalent performance (i.e., quantity filtered and filtrate quality); (2) selection of optimal operating parameters, such as filter rate, terminal head loss, and run length for a given medium application; (3) definite effluent quality performance for a given medium application; and (4) determination of the effects of pretreatment variations. Ultimate clarification of filtered water will be a function of particle size, filter medium porosity, filtration rate, and other variables.

The technology is proven in both industrial and municipal applications and is less expensive than other technologies when reductions to 10 mg/l TSS and less and very low levels of suspended metals are to be achieved. A major question in application to coal mine wastewater is the potential for gypsum fouling/blinding if lime is used for neutralization when calcium ions liberated by the dissolution of lime (CaO) combine at alkaline pH with sulfate ions. This substance will deposit on surfaces throughout the treatment system. When this material deposits on the granular media pores, water is impeded from passing across or through the filtration apparatus. This phenomena is called fouling or blinding. The problem can be abated by proper dosage of lime, recycle of sludge or use of a different neutralizing chemical. To examine the levels of suspended solids and toxic removal potential achieved by filtration technology, a treatability study was instituted by the Agency at two mines, both exhibiting normally acid mine drainage (24, 25).

The first testing program, conducted on BPT-treated acid mine drainage from a deep mine in Pennsylvania, consisted of bench scale jar tests, dual media filtration tests and backwash settling tests at the coal mine site. In addition to determination of achievable removal of suspended matter, an evaluation of possible effects of fouling caused by gypsum or excess lime was carried out. Further, a number of filtration tests were run with addition of different polyelectrolytes to ascertain their effect on filter performance. Composite samplers were used to track filter progress.

Initial flux rates for each test were established at 20 gpm per square foot of filter area. The influent to the test unit was clarifier effluent from the acid mine drainage treatment plant. The final effluent from a final settling pond was not used because the concentrations of TSS and iron were too low to provide large enough pollutant loadings to satisfactorily evaluate pollutant removal capability. Test parameters for each test run are summarized in Table VII-9. No filter test runs exhibited a significant flow reduction, including a test of 43 hours duration (test no. 9). Effluent suspended solids averages were always below 15 mg/l and, in many cases, less than 10 mg/l. This level was independent of the duration of the test run. At the end of each filter test run, the filter media were cleaned by a combination of air and water backwash. A backwash period of 10 minutes was found to be sufficient in each case to regenerate the filter.

Analytical data for the priority metals are summarized in Table VII-10. Priority metals in the clarifier effluent used as influent to the filtration apparatus were very low. In addition, no spiking of effluent for treatment was conducted. As a result, quantitative prediction of priority metals removal is not possible. Metal levels in many influents were not detectable and in no case did a priority metal have a filter effluent concentration of greater than .012 mg/l. Reductions of iron to .75 mg/l average effluent concentration from 2.8 mg/l average influent, and reduction of manganese to .063 mg/l from .17 mg/l average were achieved.

ALKALINE MINE DRAINAGE

Table VII-9

SUMMARY OF FILTRATION TESTS PERFORMED

Test No.	Polymer Added (mg/1)	Suspended Solids (mg/1)						Initial pH	Final pH
		Influent			Effluent				
		Min.	Max.	Ave.	Min.	Max.	Ave.		
1	(none)	10.2	27.4	12.8	1.2	9.2	2.6	9.2	9.2
2	-	--	--	13.6	--	--	1.4	9.4	9.2
3	-	9.9	17.8	13.3	1.6	7.0	3.0	9.4	9.1
4	-	--	--	17.4	--	--	3.8	9.5	9.1
5	-	16.2	38.8	27.8	2.8	11.4	7.8	9.3	9.1
6	-	16.4	40.6	28.6	6.1	16.1	11.0	9.2	9.2
7	1[a]	14.4	34.8	23.6	1.0	8.6	5.5	9.5	9.2
8	1[a]	--	--	21.2	--	--	5.2	9.4	9.1
9	-	--	--	20.2	--	--	7.0	9.0	8.8
10	1[b]	13.6	29.4	22.2	<1.0	13.6	7.3	9.4	9.1
11	1[b]	19.0	48.2	33.6	9.9	17.3	14.1	9.2	9.2
12	-	17.6	39.2	24.9	3.4	10.2	6.6	9.5	9.3
13	-	--	--	20.0	--	--	10.4	9.7	8.7
14	1[c]	17.8	43.0	27.8	<1.0	10.6	6.5	9.4	9.3
15	1[c]	--	--	11.4	--	--	10.2	9.2	9.0
16	-	16.2	99.4	24.0	7.0	16.4	9.8	9.8	9.5
17	-	--	--	15.4	--	--	2.8	9.9	9.7

Notes: [a] Dowell 144
[b] Magnifloc 1820A
[c] Calgon L670E

Table VII-10

ANALYTICAL RESULTS FROM FILTRATION TREATABILITY STUDY
(in ug/l unless noted)

Test No.	pH (units)	TDS (mg/l)	Ag	As	Be	Cd	Cr	Cu	Pb	Fe	Hg	Mn	Ni	Sb	Se	Tl	Zn
1																	
Influent	9.3	1400	10	<3	<1	<8	16	10	<2	1900	<.5	120	<3	<5	<3	<3	34
Effluent	9.3	1400	3	<3	<1	<8	4	6	<2	110	<.5	16	<3	<5	<3	<3	12
2																	
Influent	9.4	1400	8	<3	<1	<8	10	8	<2	1900	<.5	130	<3	<5	<3	<3	27
Effluent	9.4	1400	7	<3	<1	<8	10	9	<2	260	<.5	28	<3	<5	<3	<3	23
3																	
Influent	9.2	1350	14	<3	<1	<8	16	19	<2	280	<.5	43	<3	<5	<3	<3	22
Effluent	8.5	1400	15	<3	<1	<8	18	13	<2	2000	<.5	130	<3	<5	<3	<3	26
4																	
Influent	9.5	1400	11	<3	<1	<8	15	12	<2	2300	<.5	150	<3	<5	<3	<3	28
Effluent	9.4	1400	11	<3	<1	<8	16	13	<2	330	<.5	39	<3	<5	<3	<3	18
5																	
Influent	9.3	1400	16	<3	<1	<8	22	14	<2	3100	<.5	210	<3	<5	<3	<3	39
Effluent	9.1	1400	16	<3	<1	<8	22	13	<2	610	<.5	73	<3	<5	<3	<3	22
6																	
Influent	9.5	1400	23	<3	<1	9	26	17	<2	3200	<.5	210	<3	<5	<3	<3	44
Effluent	9.4	1400	21	<3	<1	10	26	16	<2	850	<.5	69	<3	<5	<3	<3	27
7																	
Influent	9.7	1400	28	<3	7	<8	17	<1	<2	3000	<.5	180	<3	<5	<3	<3	24
Effluent	9.4	1360	36	<3	7	<8	23	4	<2	690	<.5	54	<3	<5	<3	<3	12
8																	
Influent	9.6	1400	34	<3	7	<8	21	5	<2	3400	<.5	190	<3	<5	<3	<3	56
Effluent	9.7	1400	33	<3	7	<8	21	7	<2	860	<.5	55	<3	<5	<3	<3	12
9																	
Influent	8.9	1420	4	<3	1	<8	11	8	<2	3400	<.5	205	<3	<5	<3	<3	27
Effluent	8.9	1430	<2	<3	8	<8	<3	<1	<2	1300	<.5	98	<3	<5	<3	<3	11
10																	
Influent	9.3	1440	<2	<3	8	<8	<3	<1	<2	2600	<.5	160	<3	<5	<3	<3	16
Effluent	8.8	1430	<2	<3	7	<8	<3	<1	<2	790	<.5	55	<3	<5	<3	<3	8

Table VII-10 (Continued)

ANALYTICAL RESULTS FROM FILTRATION TREATABILITY STUDY

(in ug/l unless noted)

Test No.	pH (units)	TDS (mg/l)	Ag	As	Be	Cd	Cr	Cu	Pb	Fe	Hg	Mn	Ni	Sb	Se	Tl	Zn
11																	
Influent	9.3	1440	<2	<3	8	<8	<3	<1	<2	4100	<.5	250	<3	<5	<3	<3	26
Effluent	9.2	1440	<2	<3	7	<8	<3	<1	<2	1100	<.5	77	<3	<5	<3	<3	7
12																	
Influent	9.5	1350	<2	<3	8	<8	<3	<1	<2	2700	<.5	160	<3	<5	<3	<3	14
Effluent	9.4	1340	<2	<3	7	<8	<3	<1	<2	880	<.5	57	<3	<5	<3	<3	<3
13																	
Influent	9.7	1380	<2	<3	8	<8	<3	<1	<2	3200	<.5	178	<3	<5	<3	<3	17
Effluent	8.6	1360	<2	<3	7	<8	<3	<1	<2	1300	<.5	97	<3	<5	<3	<3	5
14																	
Influent	9.7	1410	<2	<3	8	<8	4	91	<2	3200	<.5	186	<3	<5	<3	<3	70
Effluent	9.5	1390	<2	<3	7	<8	2	2	<2	693	<.5	61	<3	<5	<3	<3	4
15																	
Influent	9.8	1400	<2	<3	8	<8	2	<1	<2	4100	<.5	223	<3	<5	<3	<3	23
Effluent	9.6	1400	<2	<3	7	<8	1	<1	<2	1400	<.5	83	<3	<5	<3	<3	5
16																	
Influent	9.7	1380	7	<3	8	<8	9	7	<2	2800	0.7	170	<3	<5	<3	<3	16
Effluent	9.4	1370	8	<3	7	<8	9	7	<2	950	1.0	57	<3	<5	<3	<3	3
17																	
Influent	9.6	1390	9	<3	8	<8	10	8	<2	2500	1.0	130	<3	<5	<3	<3	13
Effluent	9.6	1380	5	<3	7	<8	7	6	<2	430	1.0	30	<3	<5	<3	<3	<3
Average																	
Influent	---	1400	10	1.5	4.8	4.3	10.9	11.9	1	2800	.3	170	1.5	2.5	1.5	1.5	29
Effluent	---	1400	9.5	1.5	4.7	4.4	9.8	5.8	1	750	.5	63	1.5	2.5	1.5	1.5	12

Current Treatment Technology

Mines exhibiting alkaline drainage supply a majority of U.S. coal production. Raw wastewaters from these mines are generally characterized by very low metals levels and are pH neutral or slightly alkaline. Alkaline surface mines can contain high sediment loading caused by precipitation and runoff, whereas alkaline underground mines are most often low in suspended solids. Many mines with alkaline drainage can discharge the raw water without any treatment. However, most mines will have a pond or pond system installed to contain or treat runoff resulting from rainfall. Aside from precipitation and the ensuing sediment laden runoff, the major exception to mines that can normally discharge without treatment is for those mines located in geological strata containing fine clays. These colloidal clays are difficult to settle without coagulant aids. If fine clays are prevalent, chemical flocculant addition may be required to comply with BPT limitations. This, however, is an infrequent situation in the industry. Figure VII-10 depicts a typical BPT treatment system for alkaline drainage. The settling facility is identical to the sediment pond or mechanical clarifier discussed under the previous acid mine drainage subsection. Ponds installed to comply with rainfall provisions are discussed later in this section.

Candidate Treatment Technologies

Technologies applicable to alkaline mines are similar to treatment options discussed under acid mine drainage for BPT treated wastewaters. The reader is directed to the Acid Mine Drainage Candidate Treatment Technology subsection for a detailed discussion of the technologies.

PREPARATION PLANTS

Current Treatment Technologies

Wastewater from coal preparation plants, as discussed in Section V, originates from preparation plant coal separation and cleaning equipment, such as jigs, washers, froth flotation units, and wet cyclones. The water is high in coal fines which are removed prior to discharge or reuse. Economic and environmental incentives often dictate that some portion of this effluent water be recycled for plant use. Some plants operate under total recycle while others recycle only a fraction or none at all. The remainder is discharged after appropriate treatment, usually consisting of some type of sedimentation technology. This will remove the coal fines which are present as suspended solids. Figure VII-11 illustrates a typical treatment scenario for preparation plant wastewaters.

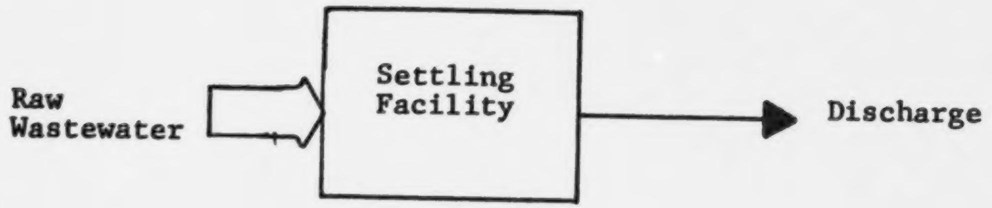

Figure VII-10
TYPICAL BPT TREATMENT CONFIGURATION FOR ALKALINE MINE DRAINAGE

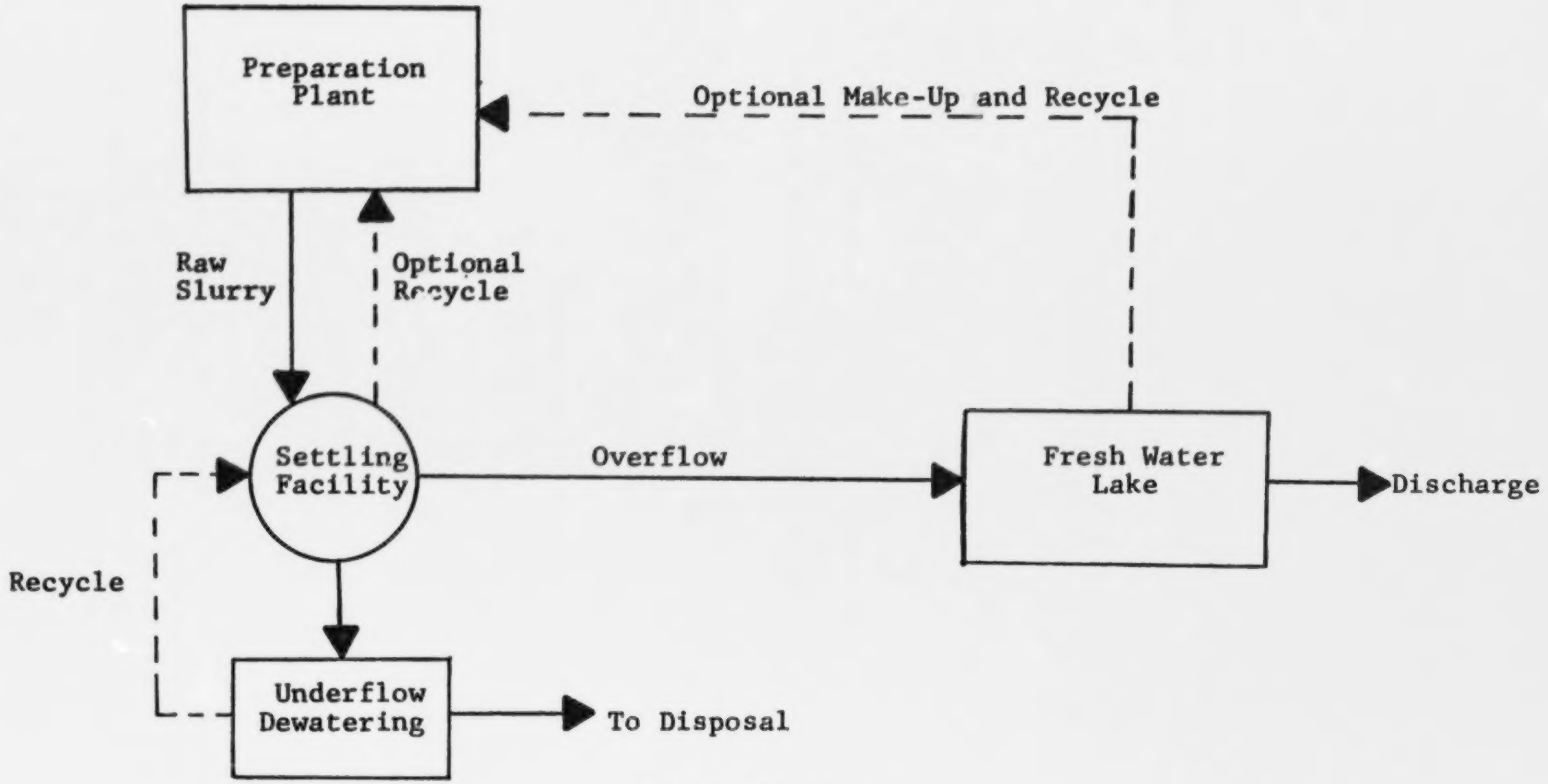

Figure VII-11

TYPICAL BPT TREATMENT CONFIGURATION FOR PREPARATION PLANT WASTEWATER

The slurry stream generated by the preparation plant usually contains fine coal refuse as a waste product from the coal cleaning process. The refuse contained in the slurry is usually 0.10 in (approximately 2.50 mm) and finer in size and frequently contains less than 10 percent by weight solids. In many cases, fine coal, clay and other mineral particles with size below 0.004 in (0.10 mm) are present. In some cases, very fine colloidal-sized material is present. These solids are removed to allow reuse or discharge of the clarified water. The settling facilities most often used are sedimentation or slurry ponds, or, where adequate land is not available, clarifiers/thickeners are frequently employed. Where the latter option is selected, dewatering by vacuum or pressure filtration is occasionally implemented within the industry to recover additional water and permit easier handling of the dewatered refuse. The water from this process is recycled to the clarifier influent and the refuse is hauled to a disposal site, a borehole, or an abandoned or active pit.

In Appalachian facilities, dewatering of the thickener underflow is commonly accomplished in a sedimentation pond for settling of the solids and recycle or discharge of the basin decant. Overflow from the clarifier/thickener is either directly recycled to the preparation plant or routed to a pond system (termed a "fresh water lake" in Figure VII-11) for eventual recycle or discharge. In many existing facilities, this latter alternative of drawing makeup from a fresh water basin is often preferred to provide a dependable water source of consistent quality for preparation plant use.

Many midwestern and western facilities employ sedimentation basins in lieu of clarifiers to provide solids removal for the refuse slurry. Basins are sometimes designed for the life of the preparation plant, but more frequently, a number of ponds are required over the operating life of the cleaning facility. As one slurry pond is silted out, slurry is diverted to a new basin. The old pond can be dredged and/or reclaimed. These sedimentation basins will often receive drainage from areas associated with the preparation plant, such as disturbed areas ancillary to the site, coal storage piles, and refuse piles. The characteristics and treatment of effluents from these three sources are discussed in the next subsection. The pond system will also frequently receive storm runoff drainage from undisturbed areas, which, in some cases, can consist of vast tracts of land.

This storm runoff is also analyzed later in this section. Decant routed from the primary slurry settling pond is commonly commingled with this undisturbed area drainage and raw or treated effluents from the associated areas in a fresh water lake. Lakes provide secondary settling prior to recycle of water required by the preparation plant. The suspended solids removal technology selected by mine operators is very dependent on the region in which the mine is located. In Appalachia and other regions where steep terrain is prevalent, thickeners and clarifiers are usually installed rather than settling basins to handle preparation plant slurries.

Those plants using a clarifier often use a coagulant aid to assist in agglomerating fine solids, resulting in greater settling rates of solids. Preparation plants that employ settling ponds for suspended solids removal do not usually inject chemical aids but instead rely on the longer retention times available to provide sufficent settling.

Candidate Treatment and Control Technologies - Existing Sources

Control technologies are particularly applicable to preparation plant wastewaters in the abatement of pollution from these sources. This includes consideration of a no discharge of pollutants requirement that would require recirculation of all water from a system treating wastewater from a preparation plant water circuit.

Total Recycle Option

To properly evaluate this option for existing sources, an examination of the definition of preparation plant wastewater is essential. For the remainder of this report, "preparation plant wastewater" is defined as any wastewater which results from processing a stream of coal to remove ash forming constituents. This wastewater consists of the following:

1. Water purposely brought into contact with run-of-mine coal to clean the coal,

2. Water collected in the waste sump resulting from spills or cleanup within the preparation plant boundaries, and

3. Runoff resulting from precipitation which enters the preparation plant wastewater treatment system.

Thus, the zero discharge requirement would effectively disallow the discharge of any pollutant-bearing water that stems from or contacts process water from the preparation plant.

To assist in the analysis of this issue, Figure VII-12 depicts the various flows into and out of the preparation plant. The types of flow streams entering the water circuit are shown on the left side of the block diagram and flows exiting the system are shown on the right side. The various sources and losses of water in the system will be discussed below in an effort to evaluate the requirements for attainment of total recycle for the preparation plant water circuit.

Water sources include:

1. Makeup Water. Water from sources external to the preparation plant and slurry water systems are almost always needed to meet the feed water requirements of the plant after using the water recycled from slurry treatment. Typical sources might be surface impoundments, mine drainage, well water, or drainage from preparation

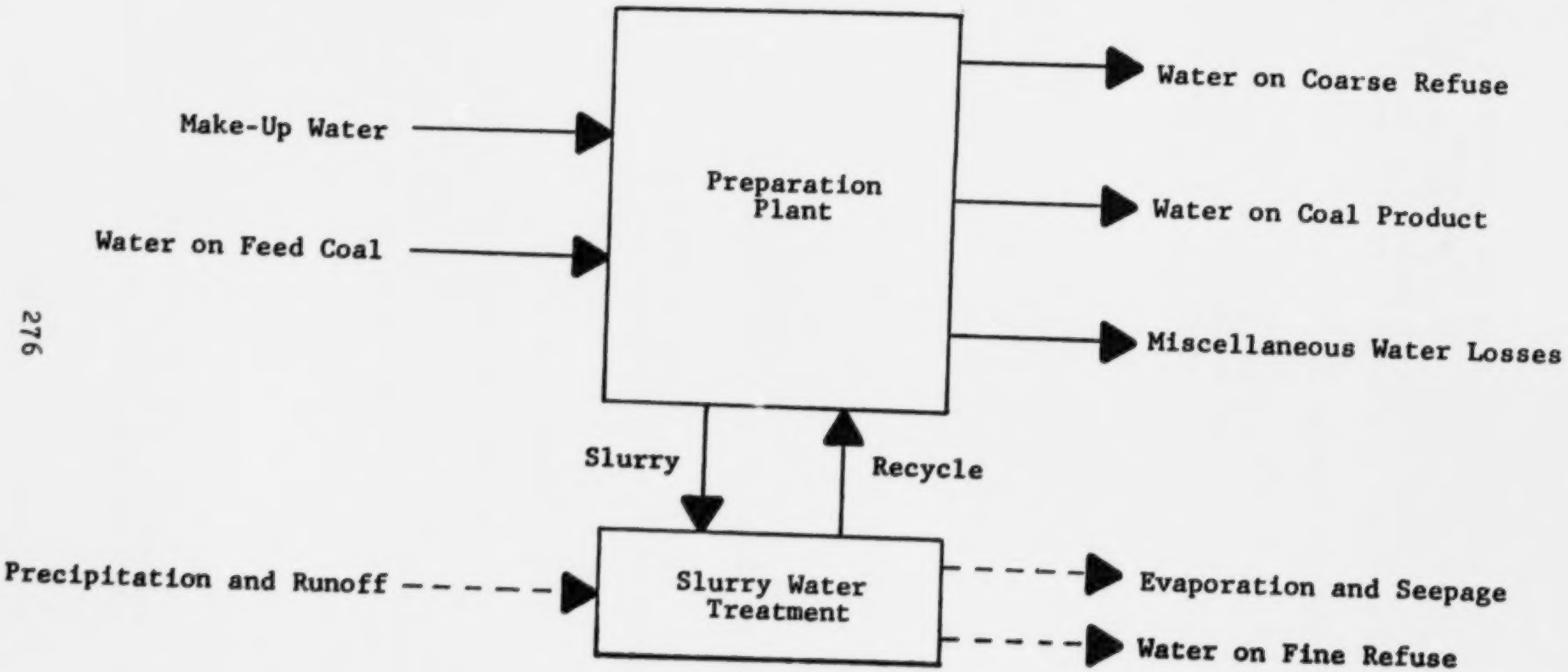

Figure VII-12

WATER SOURCES AND LOSSES IN A PREPARATION PLANT WATER CIRCUIT plant associated areas. This water should be neutral or basic to minimize corrosion problems and be relatively low in suspended solids content to avoid nozzle fouling in the plant. The volume of makeup water from sources external to the preparation plant water circuit may be zero if the slurry treatment system has sufficient capacity to store large volumes of water. In general, however, implementation of a zero discharge requirement would necessitate a makeup water source that can be throttled to balance the system.

2. Water on the Surface of Feed Coal. The coal entering the preparation plant usually has some water on the surface of the coal. This water results from dust suppression sprays in underground mined coal or from ground water in wet surface or underground mines. The raw coal also receives water as a result of precipitation falling on storage piles or on the coal as it is transported to the plant.

3. Precipitation and Runoff. The quantity of water entering the system from precipitation and runoff is governed by design and climatological factors which are both site specific. A slurry treatment system consisting of a thickener and filtration of the underflow receives precipitation only on the surface of the thickener. The amount of precipitation entering a pond system is related directly to the drainage area of the pond or ponds. The amount of runoff entering from areas adjacent to the pond system can be controlled at the design phase or as a retrofit procedure by using diversion ditching and diking as required to control inflow.

Water losses include:

1. Moisture on the coal product. This moisture leaves a preparation plant as residual water after having undergone some form of mechanical and/or thermal coal drying. The degree to which the coal material is dried is usually determined by what is necessary to achieve purchaser specifications and/or the avoidance of excessive transportation costs. The amount of water leaving with the coal will most often be greater than that entering with it since the cleaning process involves a size reduction with the attendant increase in surface area. This increase in porosity due to smaller grain sizes enhances water retention.

2. Water on Coarse Refuse. The cleaning process is designed to remove material that either does not contribute to the end use of the coal or has some deleterious effect on the use of the coal. These materials are removed as refuse by processes in the preparation plant. The bulk of this refuse leaves the plant as a surface-saturated solid after mechanical dewatering. It is dry enough to allow handling by truck or conveyor to a disposal site. The large size of this refuse makes use of wet disposal impractical. The volume of this coarse refuse will be a function of the amount of non-coal components in the plant feed and the efficiency of the separation. The total amount of water leaving the system by this route will be dependent on the amount of refuse as well as the relative size of the refuse.

3. Miscellaneous Water Lost (Drying and Evaporation). In some cases, thermal drying of the coal is required to meet product specifications. Usually, thermal drying is primarily used for the fine coal fraction. In this process, the surface moisture in the coal is reduced by evaporative losses. Water is also lost by evaporation in the plant, particularly at locations where water sprays are used in processing. Usually the water removed from the system as a result of drying and evaporation is not large compared to the total plant water requirement.

4. Evaporation and Seepage from Slurry Water Treatment. The volume and importance of these losses from the system will be a function of the design of the system as well as site specific hydrologic conditions. For example, if the slurry water treatment consists of a thickener and underflow dewatering, then seepage is nonexistent. Evaporation, although still dependent on local climatic factors, is limited to the surface area of the thickener. On the other hand, slurry water treatment by sedimentation in a pond system can result in major losses by evaporation and seepage depending upon design and maintenance of the system (e.g., surface area, lining, etc.).

5. Fine Refuse Moisture. Generally, a preparation process is designed to minimize the production of fines while achieving the desired coal quality improvement. Therefore, the fine solids which can be removed from the slurry by some combination of sedimentation (usually in mechanical thickeners or settling impoundments) and filtration usually represent a relatively small proportion of the feed material. After the fine solids have been removed in the settling facility from the bulk slurry, they will retain considerable water. Fine solids can be dewatered by filtration of the thickener underflow, and will often contain about 25 percent water by weight. The fine solids removed by sedimentation in ponds will, of course, retain greater amounts of water.

As indicated above, losses from water on the coal product and coarse refuse, as well as internal evaporative losses are insignificant in comparison to the total water flow in the plant. Closing the water circuit will primarily involve recycling of preparation plant effluents as makeup to the facility. However, the wastewater leaving the preparation plant as slurry is not suited for direct reuse in the preparation plant because of its fine solids content.

The slurry treatment process must prepare water for recycle that is relatively free of suspended solids so that its solids carrying capacity is restored for removal of similar material in the preparation plant. Solids even in fine sizes and low concentrations, can cause long term maintenance problems as a result of excessive pump and piping wear. Nozzle plugging is an additional maintenance problem for washing operations within the plant. The reuse for screen spray and wash water of thickener overflow with suspended solids less than 100 ppm has been reported. Slurry treatment must also provide recycle water which is neutral or alkaline to minimize corrosion of the process equipment.

Two primary issues can be delineated regarding a no discharge requirement. First, a total recycle system must provide sufficient water to meet process requirements while taking into account the water losses previously discussed. Second, the feasibility of segregating preparation plant wastewater from other wastewater must be assessed. Both of these factors are primarily design considerations.

A survey was conducted in cooperation with the National Coal Association in 1980 of its member companies to collect data and information specifying the design of their preparation plant slurry treatment systems. Eighty-eight member producer companies of the NCA were canvassed for profile information and water management data. These companies operate approximately 292 preparation plants. One hundred and fifty-two of these (52 percent), representing about 24 percent of the entire preparation plant industry, responded to the survey. Results from the responding facilities indicate that approximately 34 percent are currently achieving zero discharge of preparation plant wastewater. This suggests that certain facilities have adequately addressed the two issues outlined above. Other facilities have a system design that provides for a sufficiently large drainage area to continually supply preparation plant makeup water needs. Such systems resolve the first issue but are susceptible to voluminous amounts of discharge during rainfall. Plants that obtain water from this type of system would have to provide adequate freeboard in their slurry basins to accomodate the storm flows. A second way to comply would be to install a clarifier/thickener with underflow dewatering, thus obviating the need for the pond system. A third alternative is to install diking and diversion ditching around the pond system and drawing makeup water from a new source. This third alternative may also require installation of new facilities to treat the diverted runoff, particularly if acidic refuse and coal pile drainage is involved.

These alternatives are shown schematically in Figures VIII-18 and VIII-19 in Section VIII. If a facility already has a clarifier installed, changes would be confined to recycling all decant to the preparation plant and dewatering the underflow solids. This option is depicted schematically in Figure VIII-20 of Section VIII. Redesign of the clarifier or additon of equipment for chemically aided solids settling may be required to provide water of suitable quality as makeup water. Many facilities already have this flocculant addition equipment in place with their clarifiers.

However, there are certain interferences involved with coal preparation processes that may occur as a result of a total recycle system that could make an occasional discharge or purge necessary. Such interferences are:

1. Build-up of froth flotation chemical reagents, used in the froth flotation process, making the process less effective,

2. Build-up of gypsum used in pretreating the recycled water for pH adjustment interfering with both the froth flotation and gravity separation processes,

3. Build-up of slimes that interfere with gravity separation processes particularly when using heavy media vessels,

4. Build-up of TSS and tds causing scaling of pipes and plugging of nozzles,

5. Build-up of TSS and TDS that impair the use of filters used to dewater sludge from the water recycle treatment system causing a higher filter cake moisture content.

This leads to problems in refuse disposal.

Thus while total recycle with no discharge is a technically achievable control technology for some facilities, certain processes may require occasional purges from the water recycle circuit. This occassional purge allowance has been incorporated into the zero discharge option. Facilities using this purge allowance will be subject to alternate limitations (equal to BPT) while purging. The costs associated with the implementation of this alternative are presented and discussed in Section VIII.

Flocculant Addition

Flocculant addition is also a candidate BAT option for preparation plant wastewaters. Important factors characterizing this technology were previously discussed for mine drainage and will not be repeated here.

Filtration

Preparation plant wastewaters are readily amenable to this type of treatment. Gypsum is rarely evident in the normally alkaline effluents. Further, metals, if present, are in the suspended state and are thus removed by filtration. Application of this technology is feasible for both clarifier and sediment basin effluents. Achievable levels are documented in the mine drainage section.

Other Technologies

Reverse osmosis, ion exchange, electrodialysis, and sulfide precipitation are technologies applicable for dissolved solids removals. Alkaline effluents are characteristically low in undesirable and toxic dissolved metals, and thus these technologies are not considered for preparation plant wastewaters. Activated carbon and ozonation are fouled by high suspended solids, rendering them ineffective for these types of effluents. Moreover, their principal application is for a dissolved compound at a low pH value, none of which are expected in preparation plant discharges.

Candidate Treatment Technologies - New Sources

Two major options are considered for new source preparation plant discharges--a no discharge of pollutants requirement (with an occasional purge allowance) and a discharge with effluent standards achievable through application of the best available demonstrated treatment technology. These approaches are identical to that discussed for existing sources however, additional considerations are relevant for the no discharge requirement. Total recycle, even without a purge, for new sources is more easily achievable than for existing sources because water handling strategies to achieve zero discharge can be incorporated into the initial design phases such that occasional purges, if necessary, are kept to a minimum. For example segregation of other drainage from the preparation plant wastewater can be a design parameter of the system. Ponds can be located in topographical areas that do not receive large amounts of natural drainage. This will lessen the volume of storm runoff requiring diversion around the slurry treatment system. Also, if clarifier/thickeners are selected for settling, small emergency ponds can be provided to contain temporary imbalances in the water circuit arising from operational problems or exceedingly heavy precipitation on the clarifier surface. Certain flocculants to remove slime can be added, use of other pH adjustment metal remover chemicals besides lime can be used and improved sludge handling techniques can be employed. Costs for implementation of this option and of discharges employing filtration technology to polish the final effluent are presented in the next section.

PREPARATION PLANT ASSOCIATED AREAS

Current Treatment Technology

Drainage from these areas is a result of runoff from coal storage and refuse piles and other disturbed areas. This runoff has similar characteristics to untreated drainage from adjacent mines. The rulemaking published on 26 April 1977 (42 FR 21380) established limitations similar to those for active mine drainage; i.e., standards for pH, TSS, and iron (and manganese for drainage that is normally acidic prior to treatment). As a result, current treatment technology for this subcategory typically includes neutralization, aeration, and settling for acidic runoff and settling for alkaline runoff. In cases where site logistics permit, runoff is often commingled with mine drainage due to the cost advantages in joint treatment. Each of the technologies was discussed in detail in the mine drainage subsection and is not reiterated here.

Candidate Treatment Technologies

Drainage from preparation plant associated areas is often commingled for treatment with the preparation plant wastewaters. Establishment of a no discharge regulation for associated area runoff is infeasible due to the extremely wide variations in storm runoff. If such a requirement is proposed for preparation plant wastewaters in existing sources, associated area drainage would in most cases have to be segregated and treated separately. Because this wastewater is similar to mine drainage, the reader is referred to the discussion found in the Candidate Treatment Technologies portion of that subsection.

POST MINING DISCHARGES

Reclamation Areas

Current Treatment Technology

Areas under reclamation are defined as areas of land resulting from the surface mining of coal which has been returned to final contour and revegetation begun. Drainage from land that has been regraded after active mining is not currently subject to EPA regulations unless commingled with wastewater from the active mining area. OSM, under authority of SMCRA, has required that drainage from reclamation areas must be routed through a sedimentation pond. OSM has, however, proposed to delete this requirement. 46 FR 34784 (July 2, 1981). Operators have installed sedimentation ponds to treat this drainage until revegetation requirements are met and untreated drainage (influent to the ponds) meets the applicable state and federal water quality standards for the receiving stream (see 44 FR, 3 March 1979).

Candidate Treatment Technology

The Agency has conducted a sampling and analysis program under authority of Section 308 of the Clean Water Act to have 12 companies monitor influents and effluents at 24 ponds for one year. (See Appendix A). This study is summarized in more detail in the following section under "Precipitation Events." These ponds primarily receive drainage resulting from precipitation from areas undergoing revegetation, although some ponds also receive active mine drainage. Data from the program are presented in Appendix A. Total suspended solids were found at widely varying levels, due partly to differences in particle size distribution delivered to the pond from the reclamation area. These differences were large enough such that nationally applicable TSS regulations could not be developed. Settleable solids (i.e., suspended particles that will settle within one hour) and pH, however, are effectively controlled by these sediment ponds. The data also demonstrate that concentrations of the toxic metals and iron and manganese in drainage from these areas are at or very near limits of analytical detection.

The Office of Surface Mining initiated a regulatory program under the Surface Mining Control and Reclamation Act (SMRCA) to control both surface coal mining and the surface effects of underground coal mining (30 CFR Parts 700 et seq.). Section 509 of SMCRA requires coal mines to post bond securing their performance with the requirements of the Act. Liability under the bond remains for at least five years after the last year of augmented seeding, fertilizing, irrigation and other reclamation work (for at least 10 years after that time in those regions of the country where the average annual precipitation is 26 inches or less)

Liability under performance can continue for as long as necessary to achieve compliance with all requirements of SMCRA. Runoff from the disturbed areas of a surface mine must be passed through a sedimentation pond or treatment facility until the disturbed area has been restored, revegetation requirements have been met, and the quality of the drainage without treatment "meets the applicable State and Federal water quality standard requirements for the receiving stream."

EPA's regulations for post-mining discharges are consistent with the requirements of SMCRA in that effluent limitations guidelines apply only until full release of the SMCRA performance bond. The release of the bond by the appropriate SMCRA authority signifies the OSM's determination that the coal mine operator has carried out his responsibilities under SMCRA, and that post-mining pollution problems are accounted for and can be reasonably expected not to occur.

However, EPA investigated the potential need for effluent limitations guidelines after the SMCRA bond release (see Appendix C). This investigation, completed in August 1982, consisted of a telephone survey, and a literature search of information regarding effluent discharges at "post-bond" release mines. Federal, State, and public information sources were examined. As a result of this investigation, the Agency was able to develop estimates of the number of active, closed, and abandoned coal mines, but was not able to determine the number of coal mines sealed or reclaimed under SMRCA. Based on the results of this data collection effort, there is insufficient data available to support the development of regulations for post-bond release reclamation areas.

Underground Mine Discharges

Current Treatment Technology

Underground mines will often continue to discharge after cessation of coal removal from the mine. This drainage is similar in composition to the drainage that occurred during the active life of the mine, since the mechanism for generation is identical (see "Inventory of Anthracite Coal Mining Operations, Wastewater Treatment and Discharge Practices," by Frontier Technical Associates, Buffalo, N.Y., June 1980). No EPA limitations are currently established for these discharges. However, OSM standards require that this drainage be treated until either the discharge continuously meets the applicable Federal and State requirements or the discharge has permanently ceased.

Technology to control these discharges is identical to that implemented for active mine drainage. For acid discharges, this includes neutralization, aeration, and settling. Alkaline discharges require only settling. Each of these has been extensively discussed and will not be repeated here.

Candidate Treatment Technology

Each treatment technology presented in the active mine drainage sections is also considered for this subcategory.

ALTERNATE LIMITATIONS DURING PRECIPITATION EVENTS

Precipitation events can make it infeasible to meet effluent limitations on TSS, iron and manganese (see "Evaluation of Performance Capability of Surface Mine Sediment Basins" by Skelly and Loy, Engineers-Consultants, Harrisburg, Pennsylvania, July 1979). Precipitation events are beyond the control of the coal operator; thus, some mechanism should exist to temporarily exempt the facility from compliance during wet weather conditions until "dry weather" conditions return. For the coal mining industry, precipitation is the prime cause of an excursion beyond the effluent standards, particularly for total suspended solids. This is because the vast tracts of land occupied by many surface coal mines receive substantial rainfall, particularly in the Appalachian coal region.

The original exemption for storm (or snowmelt) was published in the BPT regulatory promulgation of 26 April 1977 (42 FR 21380). The exemption was provided for overflows from sedimentation ponds that were "designed, constructed, and maintained to contain or treat the discharges . . . which would result from a 10-year, 24-hour precipitation event . . .." Thus, the exemption was available regardless of the size of the hydrologic event.

On 12 January 1979, the Agency promulgated new source performance standards for the coal mining category that contained a modified storm exemption. The modification included that: (1) the burden of proof was placed on the operator to demonstrate that the appropriate prerequisites to obtaining the exemption had been met, and (2) an exemption could only be granted if a 10-year, 24-hour or larger event (or snowmelt of equivalent volume) had actually occurred. On 2 April 1979, the exemption provided for existing sources was amended to be identical to the NSPS exemption.

These actions met with substantial criticism and legal opposition by various industry trade groups, such that EPA withdrew its modified exemption provision and instituted the Skelly and Loy Study cited above to more clearly define sedimentation pond performance, particularly for those storms less than the 10-year, 24-hour event. This study concluded that sediment pond efficiency during storm events is, to a large extent, dependent on site-specific factors. The inflow hydrograph (i.e., the volume of water delivered to a pond at any given moment during or immediately after a storm) of a given storm event, and the volume and concentration of sediment delivered, will depend in each case on, among other things, the soil erodibility, length and steepness of the terrain, and cover and management practices employed at a given watershed. Moreover, the specific total suspended solids concentration in the effluent of a given sediment pond will depend on the particle size distribution of the solids delivered to the pond.

As the Skelly and Loy study demonstrates, theoretical detention times on the order of 24 hours may not be sufficient to permit settling of fine, colloidal solids. Thus, even if all of the larger solids settle, TSS effluent concentrations can vary widely depending upon the amounts of fine material present in the influent. The particle size distribution of the sediment delivered at a particular site is thus a critical factor affecting effluent quality, and is largely beyond the control of the operator. This distribution will vary not only from site to site for a given storm event, but at the same site during the course of the storm (7).

These conclusions were verified by other available literature, including an EPA study entitled, "Effectiveness of Surface Mine Sedimentation Ponds" published in 1976. This study's central conclusion was that the sediment ponds which were properly designed and maintained were measured to have high efficiencies of removal of suspended solids during the baseline sampling period. However, the efficiency of removal of suspended solids was measured to be much lower during the storm event (12).

As a result of these investigations, on 28 December 1979 (44 FR 76788), the Agency rescinded its BPT and NSPS storm exemptions and promulgated what was essentially the original BPT exemption, with the burden of proof placed upon an operator and a requirement that the overflow had been caused by an actual hydrological event.

During the course of this rulemaking, the Agency instituted two studies to investigate the appropriateness of alternate limitations during the storm exemption period. One study established the data base supporting the pH and settleable solids limitations, of 6-9 and 0.5 ml/l respectively, for reclamation areas and active mining areas during precipitation events (see Appendix A of this document). The other study determined that settleable solids can be measured below 1.0 ml/l with a reasonable degree of precision and accuracy, and that, for the coal mining industry, 0.4 ml/l is the method detection limit for this parameter (see Appendix B of this document). (This study was performed because, since proposal of this regulation, considerable public comment was submitted to EPA stating the discrepancy between the proposed 0.5 ml/l standard and the Standard Methods statement that "the practical lower limit is about 1 ml/l/hr.) These two studies are briefly discussed below in order to present the rationale behind the selection of settleable solids for regulation.

Settleable Solids

The 308 self-monitoring survey, as discussed in Appendix A, requested industry submit weekly data on their sedimentation pond performance for a one year period. Data was submitted on TSS, suspended solids, total and dissolved iron, and pH by EPA approved analytical methods. These data, with pertinent rainfall information, were to be submitted to EPA on a monthly basis.

Twenty-four ponds submitted data. Seventeen of the 24 ponds satisfy the necessary design criteria as specified in the May 26, 1982 proposal to the coal mining regulations. This specification required that in order for a facility to become eligible for a "storm exemption" the treatment facility must be able to contain the runoff resulting from a 10-year, 24-hour storm. The volume of runoff had to include the drainage from inactive (reclaimed) areas in addition to the active mining areas (undisturbed, or virgin areas were excluded from consideration). Four of the 17 ponds had no discharge. Two additional ponds were excluded from analysis because of design and operational defects.[2] Thus a total of 11 of the 10-year, 24-hour ponds submitted discharge data and satisfied the design criteria.

The facilities submitted data during both wet and dry conditions. However, analysis were only performed on the wet weather data because 1) the settleable solids limitation for active mines will only apply during precipitation events, and 2) although the settleable solids limitation will apply during all weather conditions for reclamation areas, effluent discharges at these areas are primarily a result of runoff during precipitation.

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[2] The two ponds excluded from analysis either had effluent points located very near the influent point, resulting in poor settling performance or had drainage from surrounding spoil areas at unspecified influent points to the pond. This was not the case for the other ponds.

These eleven ponds submitted a total of 262 measurements taken during wet weather conditions of which 4 exceeded settleable solids value of 0.5 ml/l. Thus, 98.47% of the measurements were less than or equal to this value.

A stastical analyses was performed on these results and is presented in Appendix A. On the basis of this analysis, the Agency concluded that the 0.5 ml/l value is consistent with the 99% compliance criterion used for establishing effluent limitations.

Furthermore, similar analyses were performed on data from 18 ponds regardless of size, (excluding from the original 24, the 4 ponds without discharge, and the two that were improperly designed). There were a total of 414 observations from these ponds of which 7 exceeded the effluent limit of 0.5 ml/l for settleable solids. Thus, 98.31% of the measurements were less than or equal to this value. Again, analyses of these data showed the 0.5 ml/l limitation to be consistent with the 99% compliance criterion.

Thus, analysis of the available settleable solids data from coal mining sedimentation ponds demonstrates that the proposed limit of 0.5 ml/l is consistent with Agency policy for effluent guidelines of 99% compliance. Statistical analysis shows that the observed exceedance rate is not significantly different from 1%. This conslusion holds regardless of whether or not the size criterion for ponds specified in the proposed regulation is considered.

Even though the technology basis behind the 0.5 ml/l limitation is a 10-year, 24-hour pond, the analysis shows that even smaller ponds can achieve this limitation. Therefore, any type of treatment facility such as smaller ponds, diversion ditching, or diking can qualify for alternate limitations during precipitation events as long as the limitations are met.

The deletion of the pond design criteria is also consistent with the OSM proposed regulations which have deleted this requirement as well.

Comments were submitted regarding their concern over a 0.5 ml/l settleable solids limitation because Standard Methods suggest that the "practical lower limit is about 1.0 ml/l." Therefore, EPA conducted a study to determine the precision and accuracy of measuring settleable solids below 1.0 ml/l (see Appendix B). This study concluded that not only can settleable solids be measured below 1.0 ml/l but that the maximum method detection limit for this parameter is 0.4 ml/l. The method detection limit is defined as the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero and determined from analyses of a sample in a given matrix containing sample. A description of the procedure to calculate the method detection limit is presented in Appendix B or can be found in Environmental Science and Technology, "Trace Analyses for Wastewaters," Vol. 15, No. 12, December 1981, Page 1426.

This study involved field and laboratory determinations of the method detection limit using samples collected at 8 different sedimentation ponds. Samples were analyzed using the Imhoff cone method as specified in Standard Methods for the Examination of Water and Wastewater and 304(h) of the "EPA's methods for Analysis of Water and Wastewater".

Settleable solids analyses were first conducted in the field. Seven aliquots were prepared for each sample and placed in Imhoff cones. Each aliquot was read by three independent observers. The seven aliquots were then recombined into one sample and shipped to EPA's laboratories whereby the same procedure was repeated only under more controlled conditions. A method detection limit was then determined from the results of these samples.

There were a total of eight samples (one from each pond) measured on site. The method detection limits determined from these samples ranged from 0.04 ml/l to 0.40 ml/l with an arithmetic average of 0.22 ml/l. Out of the 10 samples sent to and measured in the laboratory (2 were duplicates), the method detection limit ranged from 0.05 ml/l to 0.20 ml/l with an arthmetic average of 0.12 ml/l. (Laboratory results are typically lower because of the more controlled conditions under which samples are analyzed). In an effort to derive a practical method detection limit representative of industrial conditions, a method detection limit based on the field determinations is deemed most appropriate. In addition, rather than establish the method detection limit based on the average value a more conservative approach is to base the method detection limit on the maximum value.

Thus, this study concluded that 1) settleable solids can be read below 1.0 ml/l and 2) a method detection limit of 0.4 ml/l should be established for the coal mining industry.

The results from both studies concluded that the 0.5 ml/l settleable solids limitation is achievable and measurable and therefore is an appropriate and effective means of sediment control both for active mines during precipitation events and for reclamation areas.

SECTION VIII

COST, ENERGY AND NON-WATER QUALITY ISSUES

INTRODUCTION

The principal purpose of this chapter is to present results of a cost analysis for treatment technologies within each subcategory. Energy requirements and nonwater quality impacts such as solid waste generation and air pollution are also discussed for each treatment system. To conduct this analysis, a model plant approach was utilized. The first step in this procedure is to estimate average and maximum flow volumes and other design parameters. This was accomplished by review of pertinent literature and site visits to operating coal mines. From this information, capital and operating cost curves are prepared to reflect each component of the treatment system. These component costs are then assembled into overall costs for an entire treatment system or level. Energy usage for each technology is also computed.

A detailed breakdown of this section's summarized costs is presented in a cost manual developed as a part of this project (1), which is included as a supplement to this document. Additional assumptions and backup cost data are found in Appendix A of the Proposed Coal Mining Development Document (EPA 440/1-81/057-b), and in reference (2).

The final step in the cost analysis was to verify the accuracy of model plant costs with actual costs at an active coal mine. This was achieved by first visiting various mines and collecting design and cost information and then computing system costs for that mine. The results, which are presented in Appendix A in the Proposed Coal Mining Development Document, were then compared with the model plant costs, using the actual flow at that mine. Treatment methods such as reverse osmosis, electrodialysis, carbon adsorption, ion exchange, sulfide precipitation, and ozonation were initially considered as possible treatment processes for attaining BAT or NSPS compliance. These treatment systems are not included in this section because these systems are not feasible for reasons previously discussed. Table VIII-1 summarizes capital and operating costs for these systems based on a flow of 1.0 mgd.

Note: Costs presented are based on estimates prepared in 1978 and 1979. These costs can be converted to 1982 dollars (or appropriate year) by using the Engineering News Record (ENR) Construction Cost

Table VIII-1

CAPITAL AND OPERATING COSTS OF ALTERNATE TREATMENT TECHNOLOGIES NOT RECOMMENDED FOR BAT

	Pollutants Treated	Capital Cost ($1,000's)	Operating Cost ($/1,000 gal)	Source
Carbon Adsorption	Organics and heavy metals	2,000	1.37 - 1.64	(1)
Ion Exchange	Dissolved solids and heavy metals	500 to 1,000	1.00 - 1.90	(6)
Reverse Osmosis	Dissolved solids and heavy metals	500 to 1,000	0.95 - 1.90	(6)
Electrodialysis	Dissolved solids and heavy metals	500	0.80 - 1.00	(6)
Ozonation	Cyanide Reduction	240	0.20 - 0.25	(1), (7)
Sulfide Precipitation	Heavy metals	No applicable data available	No applicable data available	

Basis: 1.0 mgd facility; 1979 dollars.

Index. For example the index for 1978 is 2,776 and 1982 is 3,730. (See "Engineering News Report," March 18, 1982, for index listings). Dividing the 1982 index by the 1978 index yields a factor of 1.34. Compliance costs in 1978 dollars can be multiplied by this factor to derive costs in 1982 dollars.

MINE DRAINAGE

Existing Sources

Treatment Levels

Four treatment systems (designated levels 1, 2, 3, and 4) were identified as the basis for the cost analysis. These systems incorporate the technically feasible technologies discussed in Section VII, as outlined below.

Level One. This system is typical of a BPT treatment configuration. As shown schematically in Figure VIII-1, this scheme consists of optional raw water holding for equalization, neutralization if required for acid drainage, optional aeration, settling, and optional sludge dewatering. Some type of pH monitoring and control is required.

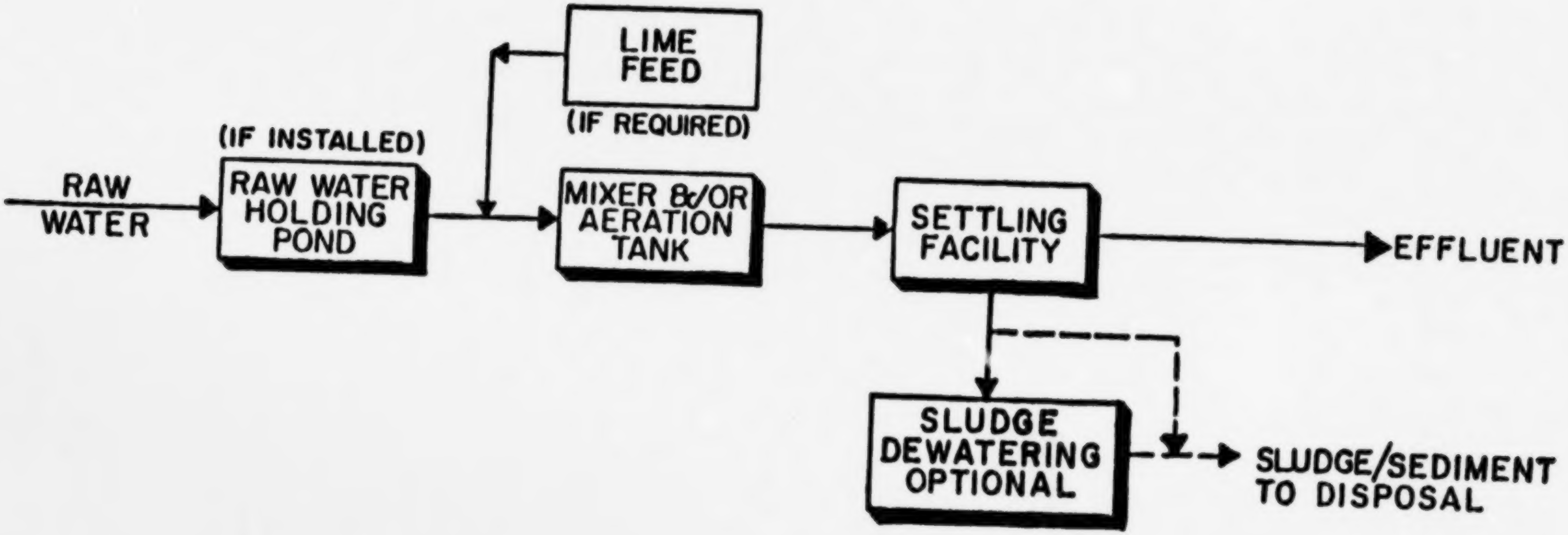
Level Two. This level consists of installing "add-on" equipment to the present BPT facilities to permit the addition of a flocculant aid. The flocculant aid is normally an organic polyelectrolyte added to promote agglomeration and subsequent settling of finer suspended solids. This level is depicted schematically in Figure VIII-2.

Level Three. This level, shown schematically in Figure VIII-3, consists of mixers and flocculator-clarifiers in lieu of sedimentation basins, and also additional chemical feed, mixing and aeration facilities. More sophisticated chemical and pH monitoring and control facilities are also included. This level of treatment would be applicable to a major upgrade of existing BPT facilities or where a mine was meeting BPT requirements without treatment facilities and would chose this treatment system to comply with BAT limitations.

Level Four. This level consists of the addition of granular media filtration to one or more of the first three levels of treatment. This technology is depicted in Figure VIII-4.

Capital Costs

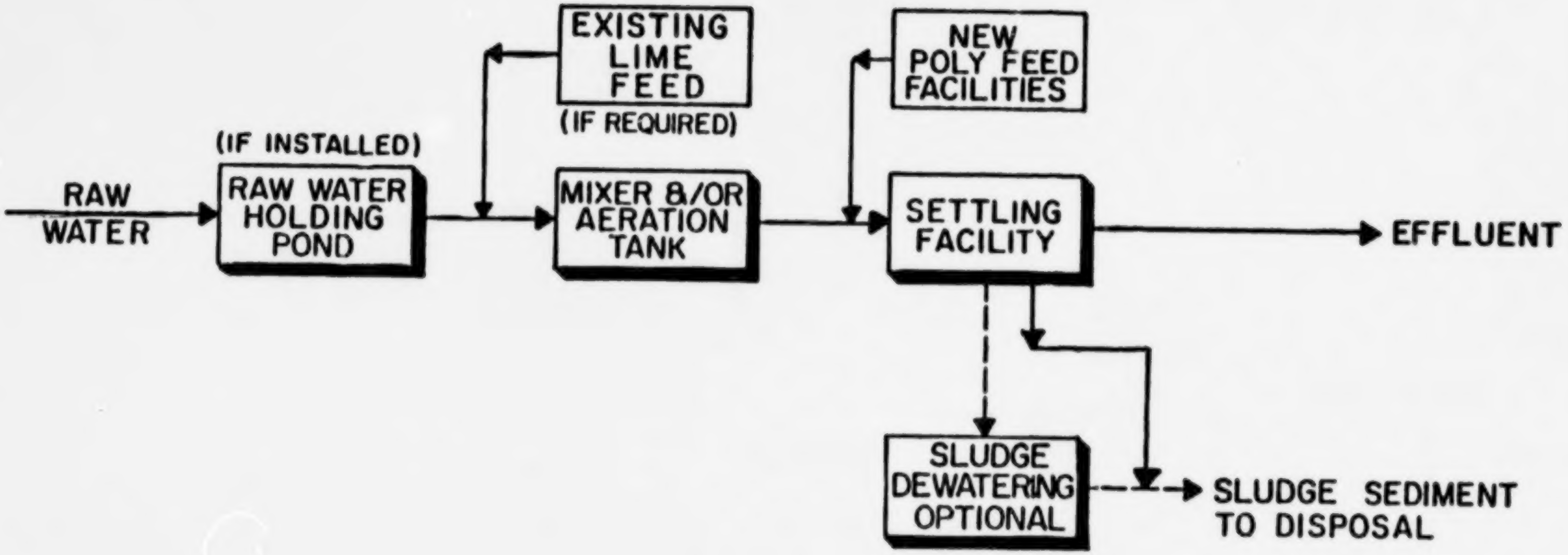
Capital cost estimates were prepared for each level of treatment, in most cases for ranges between 0.02 and 9 million gallons per day



NOTE:

AERATION STEP NOT USED FOR WATERS CONTAINING NON-FERROUS IRON.

Figure VIII-1
SCHEMATIC OF LEVEL 1 (BPT) FACILITIES



NOTE:

AERATION STEP NOT NORMALLY USED FOR WASTE WATERS CONTAINING NON-FERROUS IRON.

Figure VIII-2

SCHEMATIC OF LEVEL 2 SYSTEM TO TREAT ACID DRAINAGE

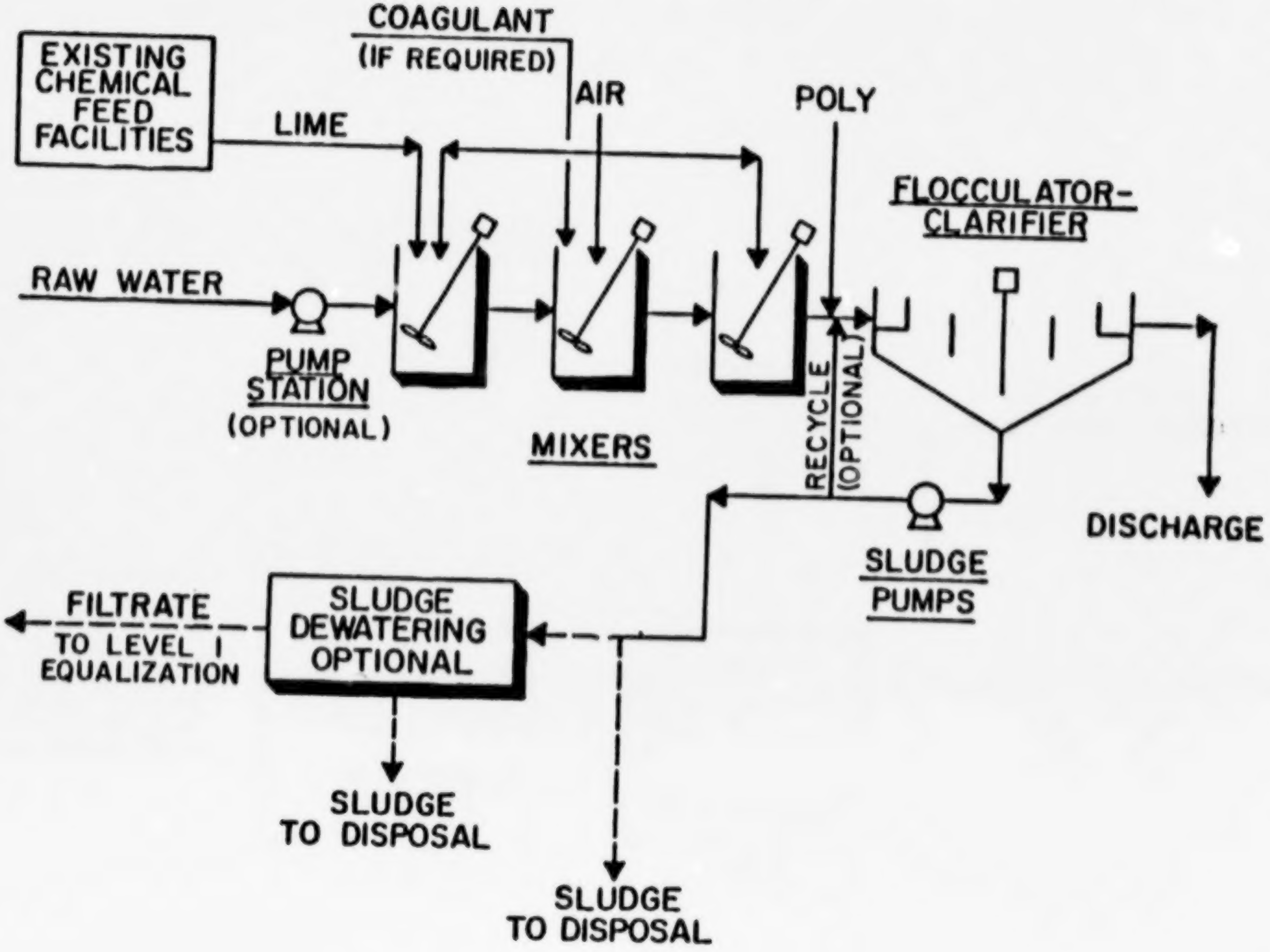


Figure VIII - 3

SCHEMATIC OF LEVEL 3 MINE WATER TREATMENT SYSTEM

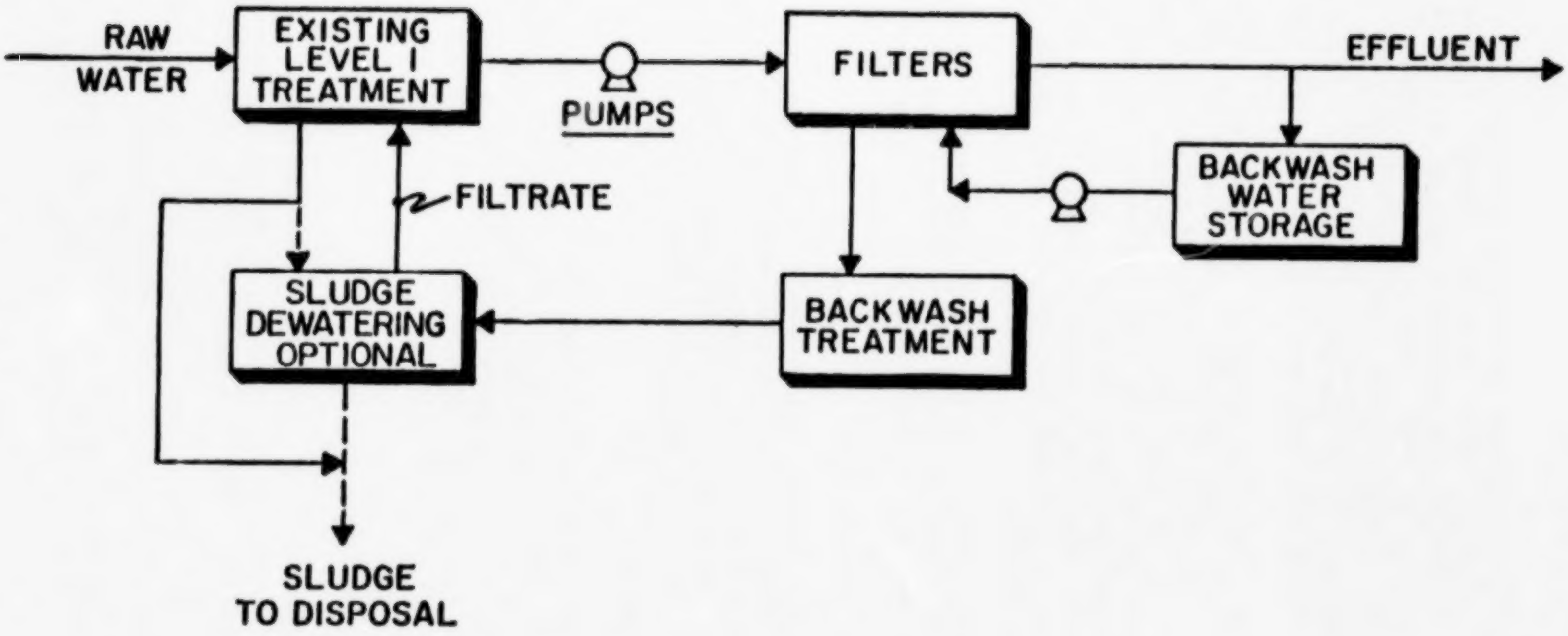


Figure VIII-4

SCHEMATIC OF LEVEL 4 - FILTRATION OF LEVEL 1 EFFLUENT ACID MINE WATER (mgd). These flows cover the range of more than 99 percent of active discharging mines. The capital costs for each level of treatment include the purchase and installation of all necessary equipment but, in most cases, do not include land, power lines, access roads or sludge disposal costs. These costs are presented separately. Level 1 has not been costed since it is assumed to be installed to meet the BPT requirements. A 25 percent factor is included in the capital cost curves to account for engineering, administration, and contingencies.

System Capital Cost for Level 2 Treatment. The level 2 treatment system provides for polymer addition as an aid in the removal of suspended solids in mine drainage (acid or alkaline). Equipment for the mixing, storage and feeding of polymer can be operated over a wide range of flow rates. Only two different polymer systems are required to cover the entire flow range of 0.02 to 4.5 mgd level (1). The capital costs for the treatment level 2 systems are $30,000 for flow rates up to 0.75 mgd and $40,000 for flow rates greater than 0.75 mgd including an enclosure.

System Capital Costs for Level 3 Treatment. Figure VIII-3 presented a schematic of the equipment included in the level 3 treatment system. This system includes a pump station, mixing tanks, clarifiers, and a control building. The capital costs are presented as a function of flow rate in Figure VIII-5.

System Capital Costs for Level 4 Treatment. The equipment and facilities comprising this treatment system are pump station, gravity filters, backwash water storage tank, and control building. A schematic diagram of this system was presented in Figure VIII-4. The capital cost curve is shown in Figure VIII-6.

Land Requirements

The land requirements computed for treatment levels 3 and 4 are presented in Figure VIII-7. The land required for level 2 should be minimal and is included with the capital cost. Once the land area that is needed from a particular treatment level is known, then this value can be multiplied by the cost per acre at the site in question. For the purposes of this report the cost per acre is assumed to be $4,000.

Annual Costs

Level 2. Table VIII-2 provides a breakdown of annual costs associated with level 2 treatment system. By incorporating the appropriate amortized capital cost and polymer cost, Figure VIII-8 was generated.

Level 3. The annualized costs and energy requirements for level 3 treatment are computed in the same manner as those for level 2. Polymer addition is also included in this treatment level and the annualized cost and energy curves are presented in Figure VIII-9 with a two mg/l polymer dosage. In this treatment system, two operators

Table VIII-2

BREAKDOWN OF ANNUALIZED COST FOR LEVEL 2 TREATMENT SYSTEM

	0.015-1.0 mgd	1.0-4.5 mgd
1. Capital Recovery		
Construction: 0.10608 x Cc	$ 500	$ 900
Mechanical: 0.16725 x Cc	3,200	5,100
TOTAL	$3,700	$6,000
2. Operating Personnel		
	$9,000	$9,000
3. Maintenance		
(Materials & Supplies) (@ 3% of Capital Cost)	$ 900	$1,200
4. Chemicals		
(@ $2/lb & 365 days/year) (function of flow rate and dosage)	$91-46,000	$6,000-274,000
5. Energy		
(@ $0.03/kW-hr, 24 hr/d, 365 d/yr)	$ 400	$ 700

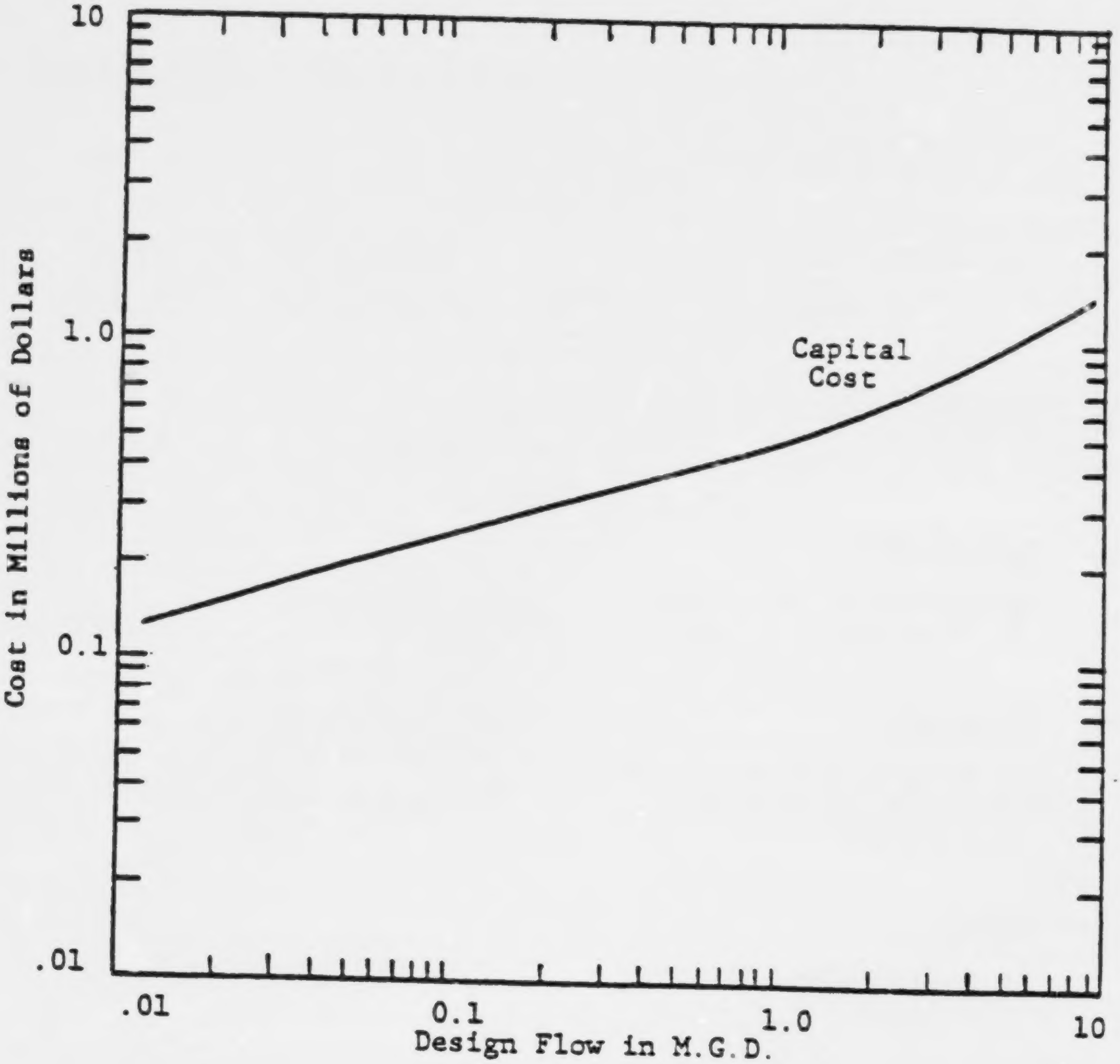


Figure VIII-5
LEVEL 3 TREATMENT OF MINE DRAINAGE -
CAPITAL COST VERSUS FLOW RATE

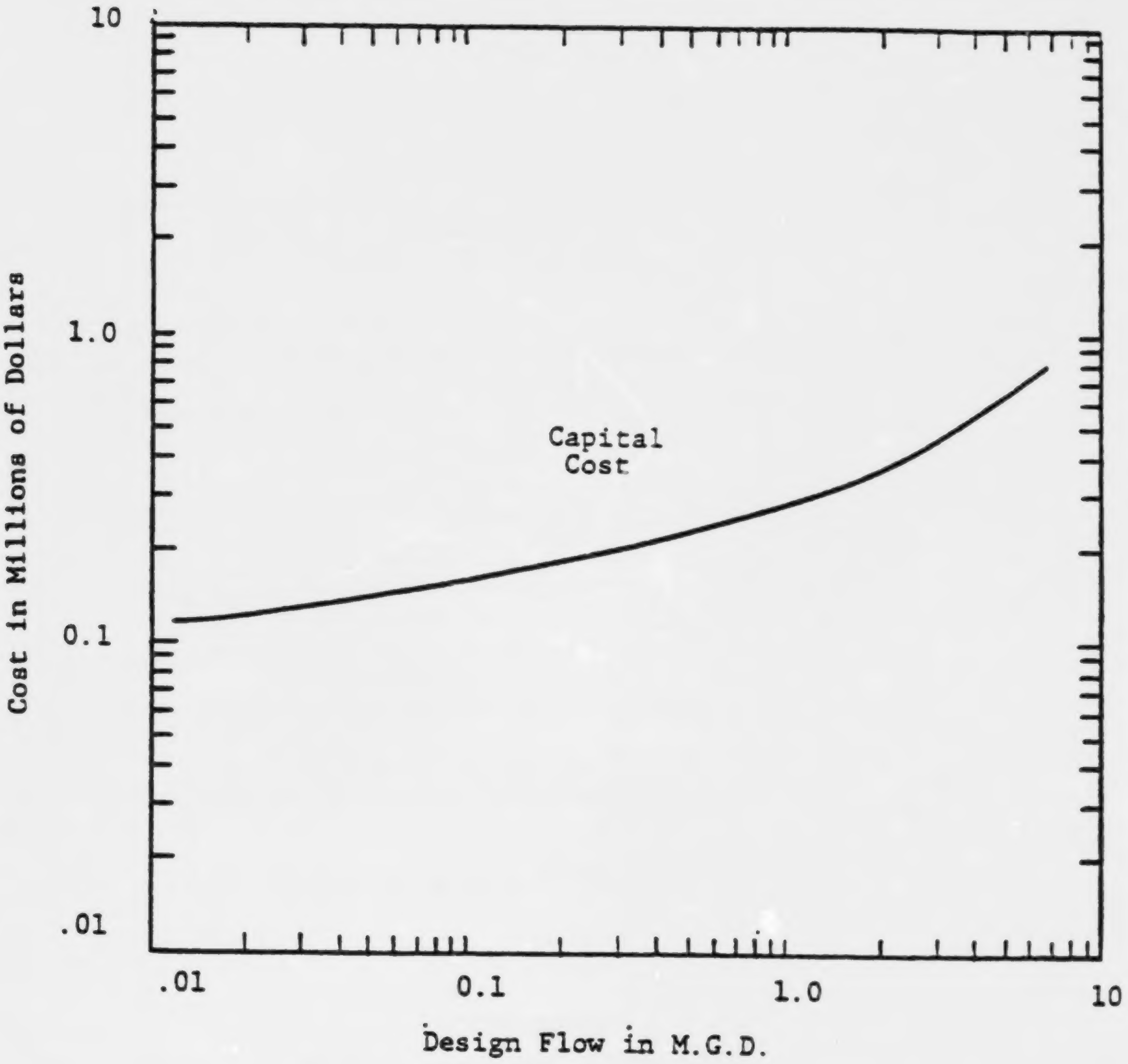


Figure VIII-6
LEVEL 4 TREATMENT OF ACID MINE DRAINAGE BY FILTRATION CAPITAL COST VERSUS FLOWRATE

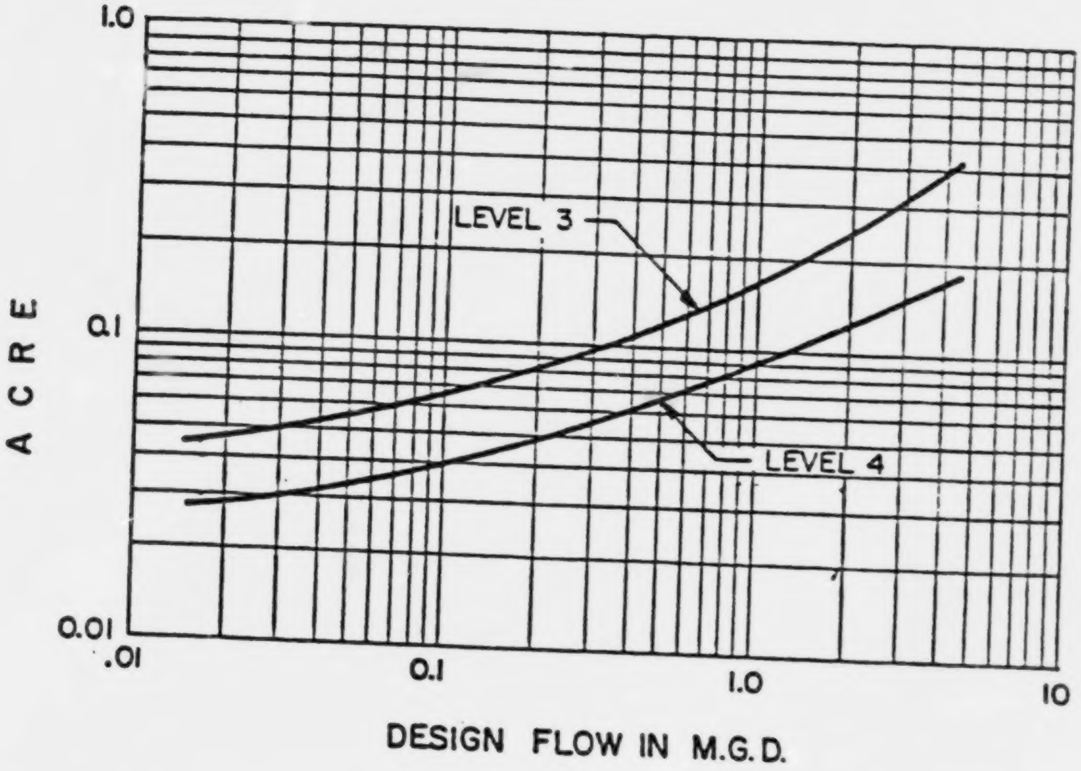
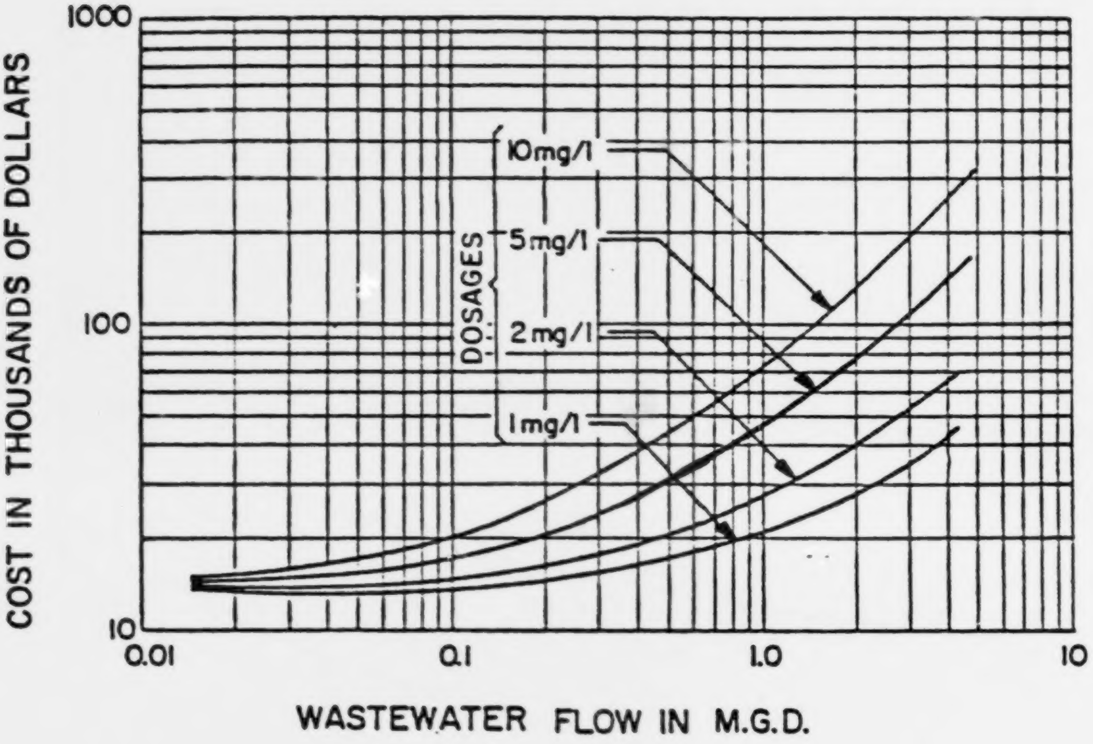


Figure VIII-7

MINE WATER TREATMENT SYSTEM
DESIGN FLOW VERSUS LAND AREA
REQUIREMENTS



NOTE:

CAPITAL COST IS:
FOR FLOW ≤750,000 gpd — $30,000
≥750,000 gpd — $40,000

Figure VIII-8

WASTEWATER TREATMENT FLOCCULANT (POLYMER) ADDITION ANNUAL COST CURVES AND CAPITAL COST DATA

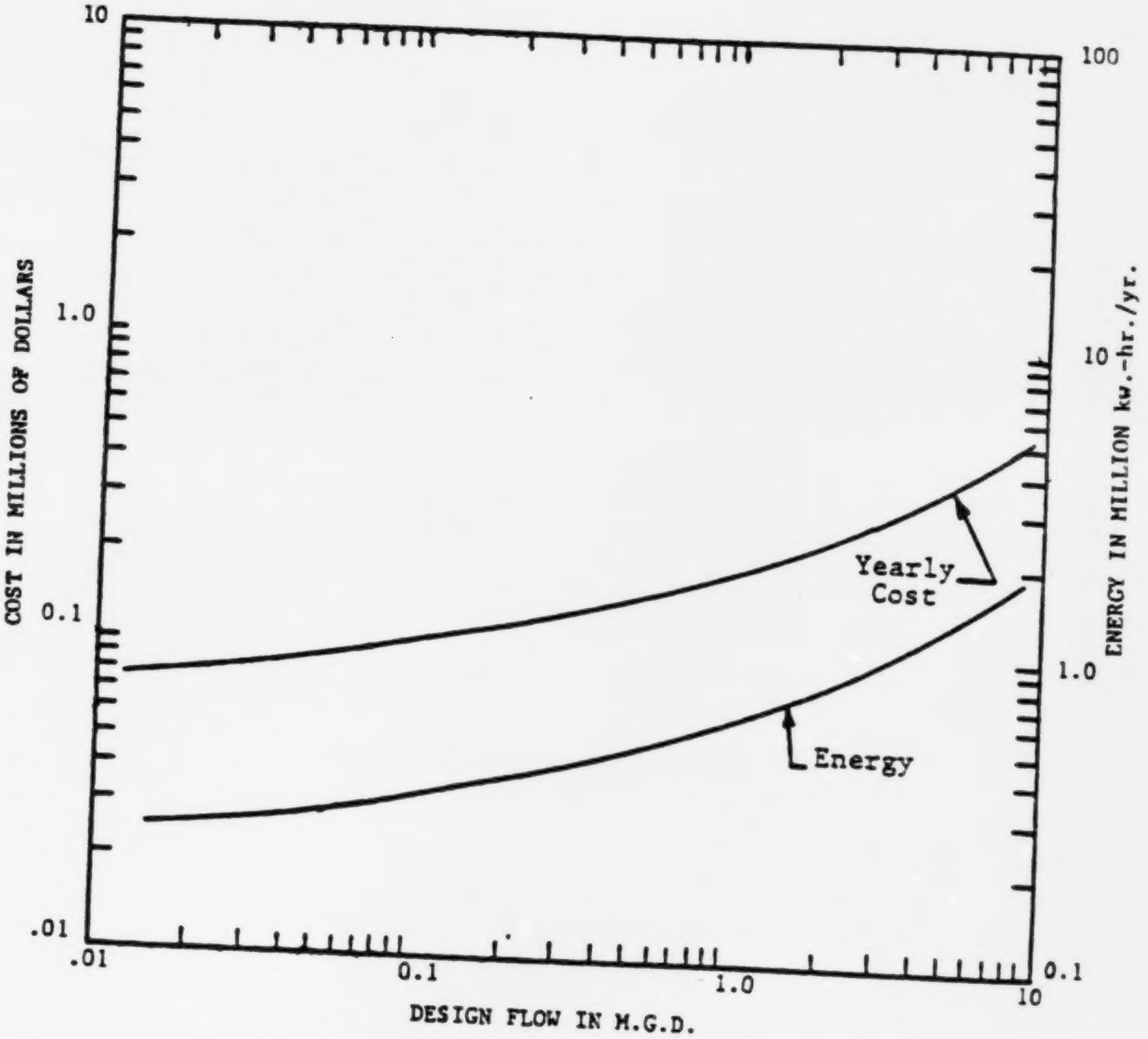


Figure VIII-9

TREATMENT LEVEL 3 ANNUALIZED COSTS AND ENERGY REQUIREMENTS VERSUS MINE DRAINAGE FLOWRATES per shift are assumed for flow rates up to 0.75 mgd; above 0.75 mgd, three shift operators are required.

Level 4. Annualized costs and energy requirements for level 4 treatment were estimated by the same process used for level 2 and are presented in Figure VIII-10. Only one operator per shift is required for this system.

New Sources

Four treatment levels were also established for new sources in the mine drainage subcategory. These levels correspond closely to the treatment levels under existing sources, with only minor modifications in levels 3 and 4. As shown in Figure VIII-11, level 3 for new sources would include recycle of filtrate from sludge dewatering equipment to the head of the treatment plant. Level 4 for new sources is modified to include levels 1, 2, or 3, as shown in Figure VIII-12.

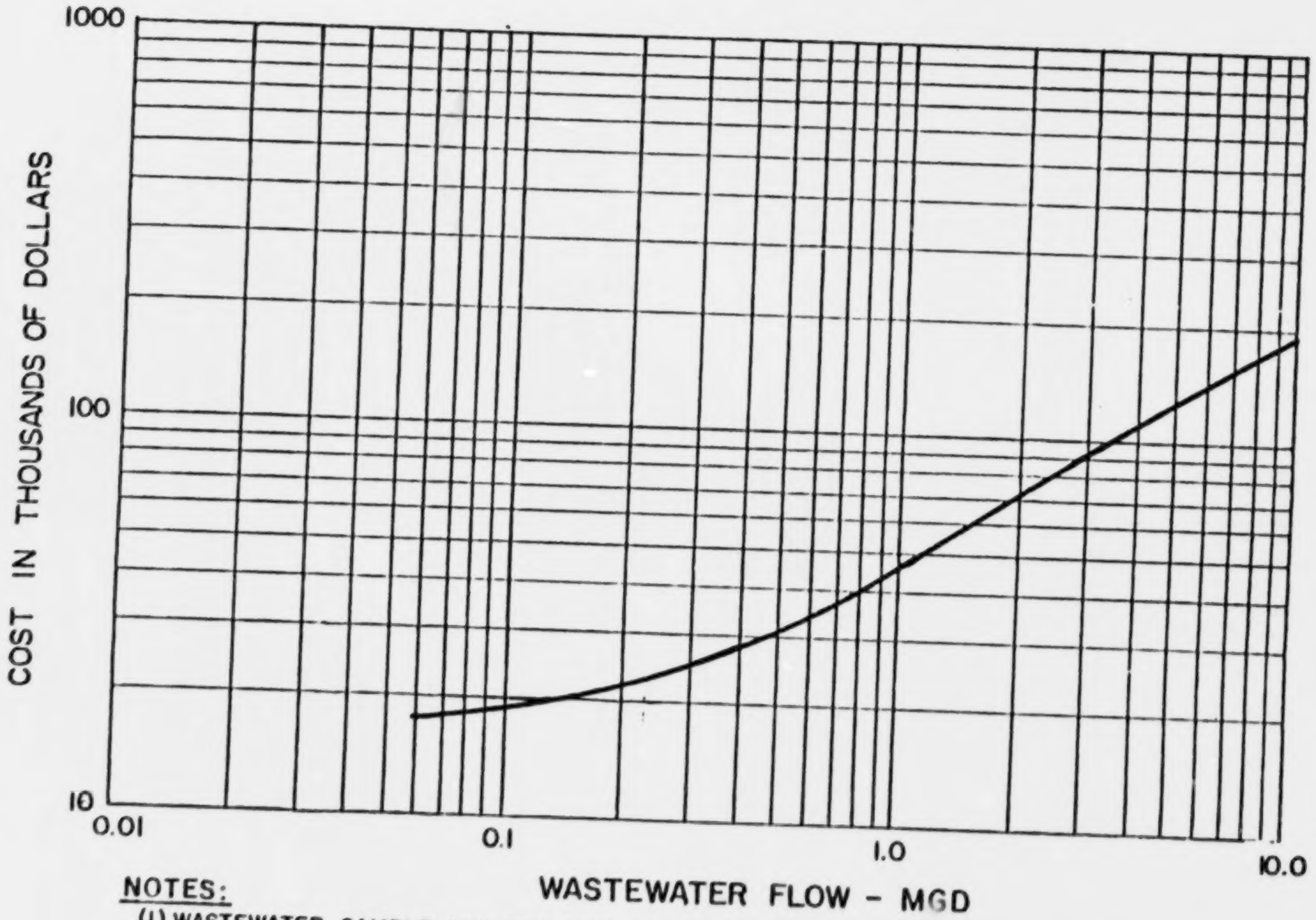
Capital Costs

The capital cost assumptions for new sources are identical to those made for existing sources, with one major exception. New sources by definition do not have any existing treatment installed, while existing sources were assumed to have BPT or equivalent in place. Therefore, new source capital (and annual) cost estimates must include the cost of BPT facilities as well.

System Capital Costs for Level 1 Treatment. The level 1 treatment system provides for the construction of a sedimentation basin or clarifier to remove suspended matter from mine drainage (acid and alkaline). The capital costs for sedimentation ponds are presented in Figure VIII-13. If lime feed equipment is required and the dosage known, Figure VIII-14 can be used to determine the cost of installed equipment.

System Capital Costs for Level 2 Treatment. The level 2 treatment system provides for the construction of a sedimentation basin for polymer addition as an aid in the removal of suspended matter in mine drainage (acid or alkaline). The capital costs for sedimentation ponds are presented in Figure VIII-13. Since the sedimentation pond sizing is based on the area storm runoff while the polymer addition equipment is based on the dry weather flow, it is infeasible to prepare cost curves of combined sedimentation basins and polymer addition equipment costs. Therefore separate curves are presented. The capital costs for the polymer addition systems are $30,000 for flow rates up to 0.75 mgd and $40,000 for flow rates greater than 0.75 mgd including an enclosure.

System Capital Costs for Level 3 Treatment. This system includes a pump station, mixing tanks, clarifiers, and a control building. The capital costs were presented as a function of flow rate in Figure VIII-5.



NOTES:
(1) WASTEWATER SAMPLE ANALYSIS NOT INCLUDED. (2) LOADING RATE = 10 GPM/FT^2

Figure VIII-10

LEVEL 4 WASTEWATER TREATMENT ANNUAL COST CURVE

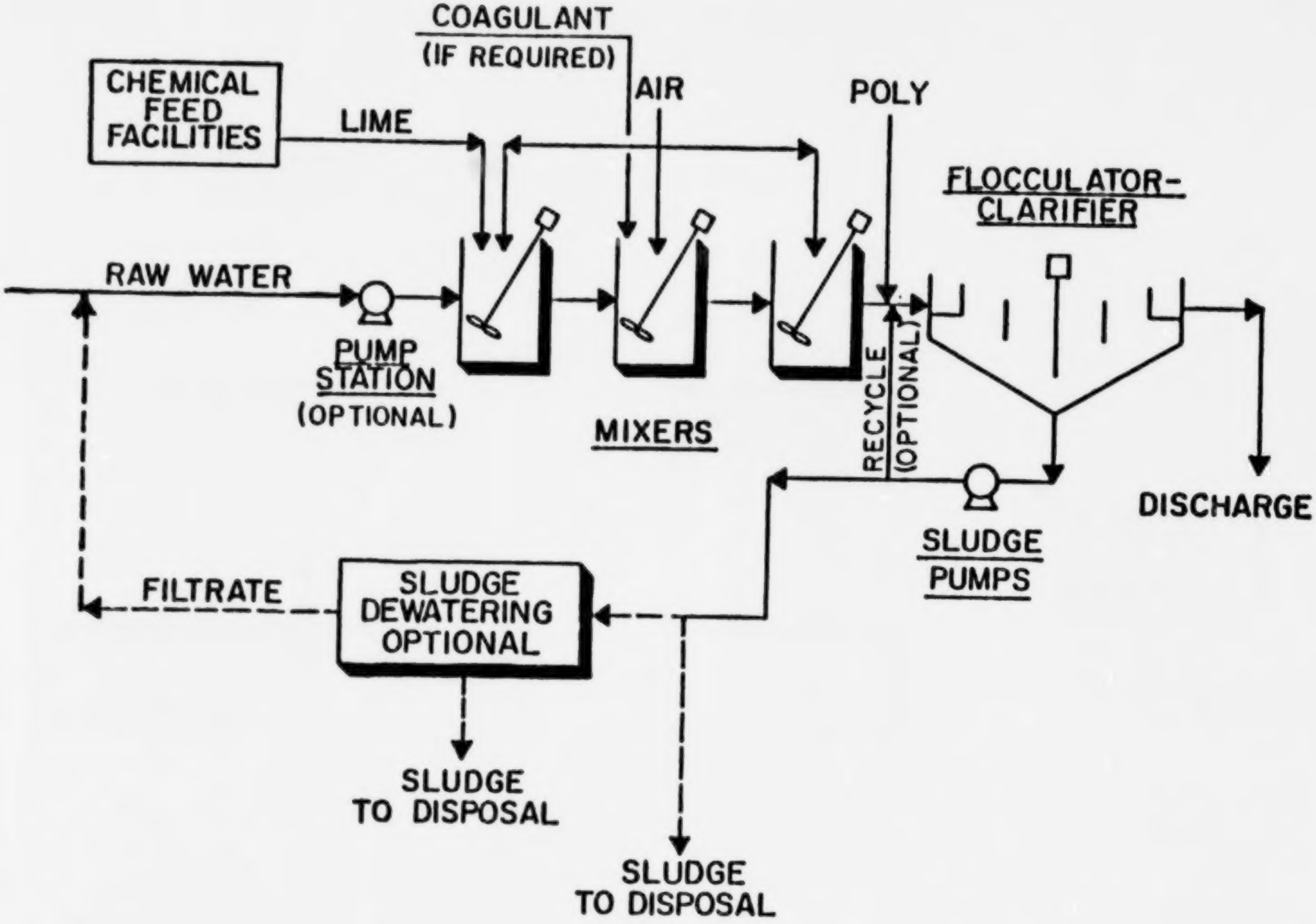


Figure VIII-11
SCHEMATIC OF LEVEL 3 NSPS FACILITIES

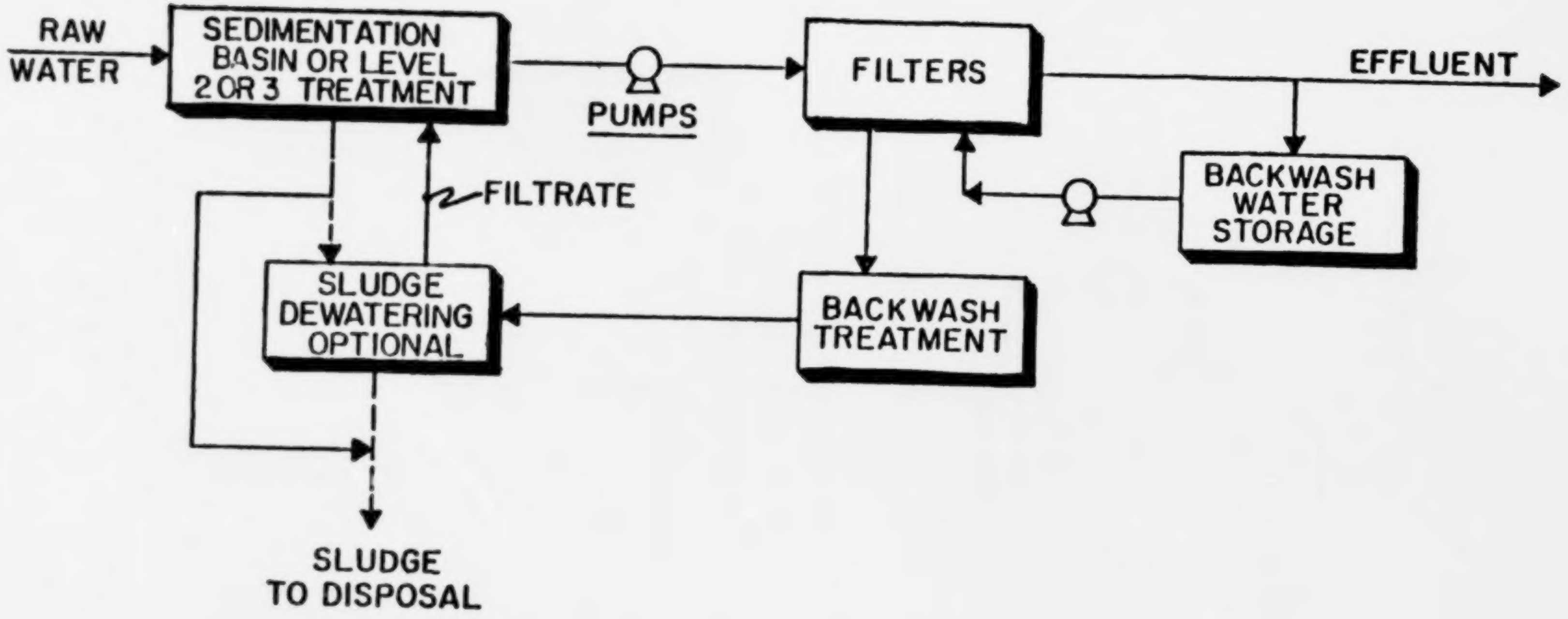


Figure VIII-12
SCHEMATIC OF LEVEL 4 NSPS FACILITIES

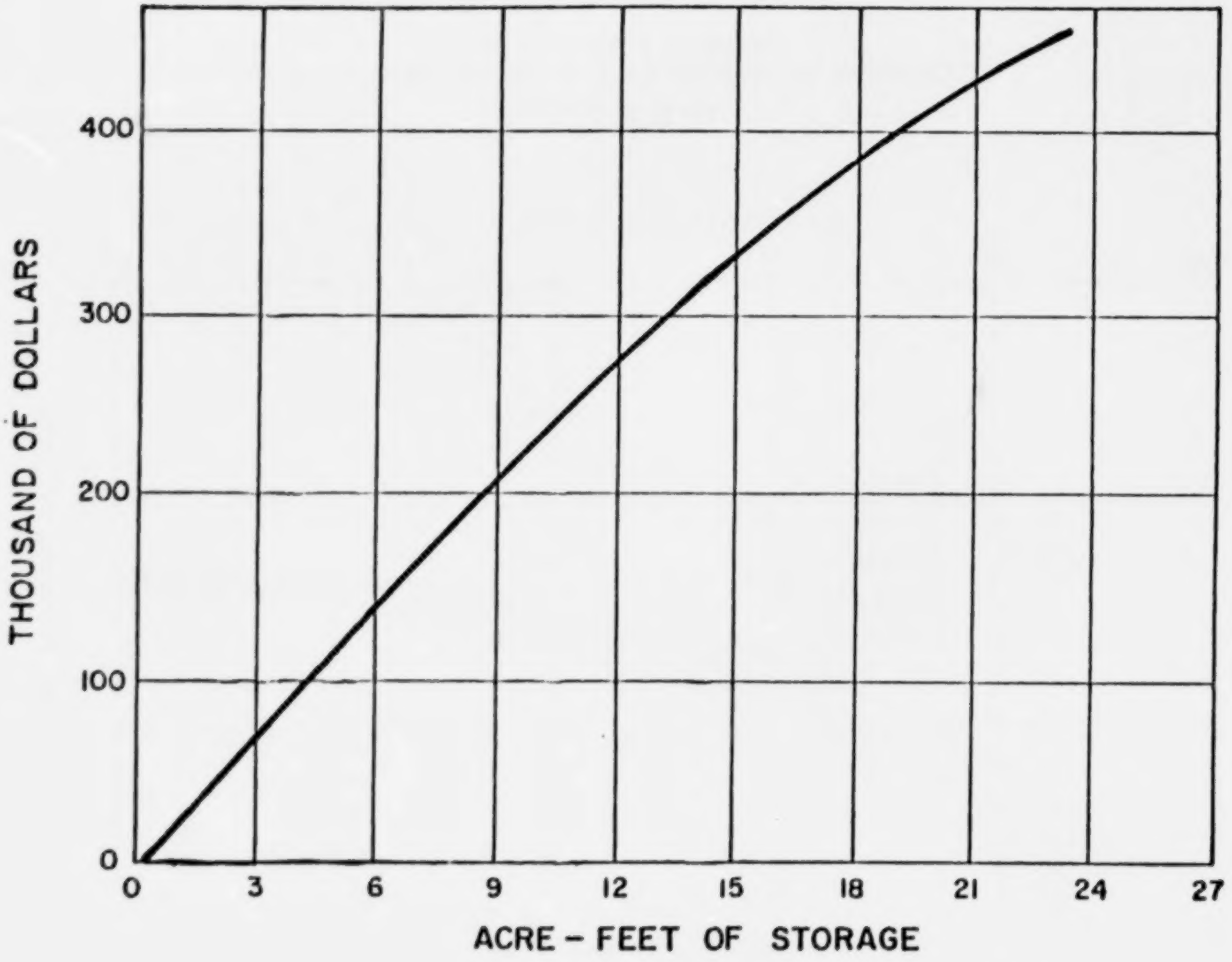


Figure VIII-13

WASTEWATER TREATMENT SEDIMENTATION POND STORAGE
VERSUS CAPITAL COST CURVE

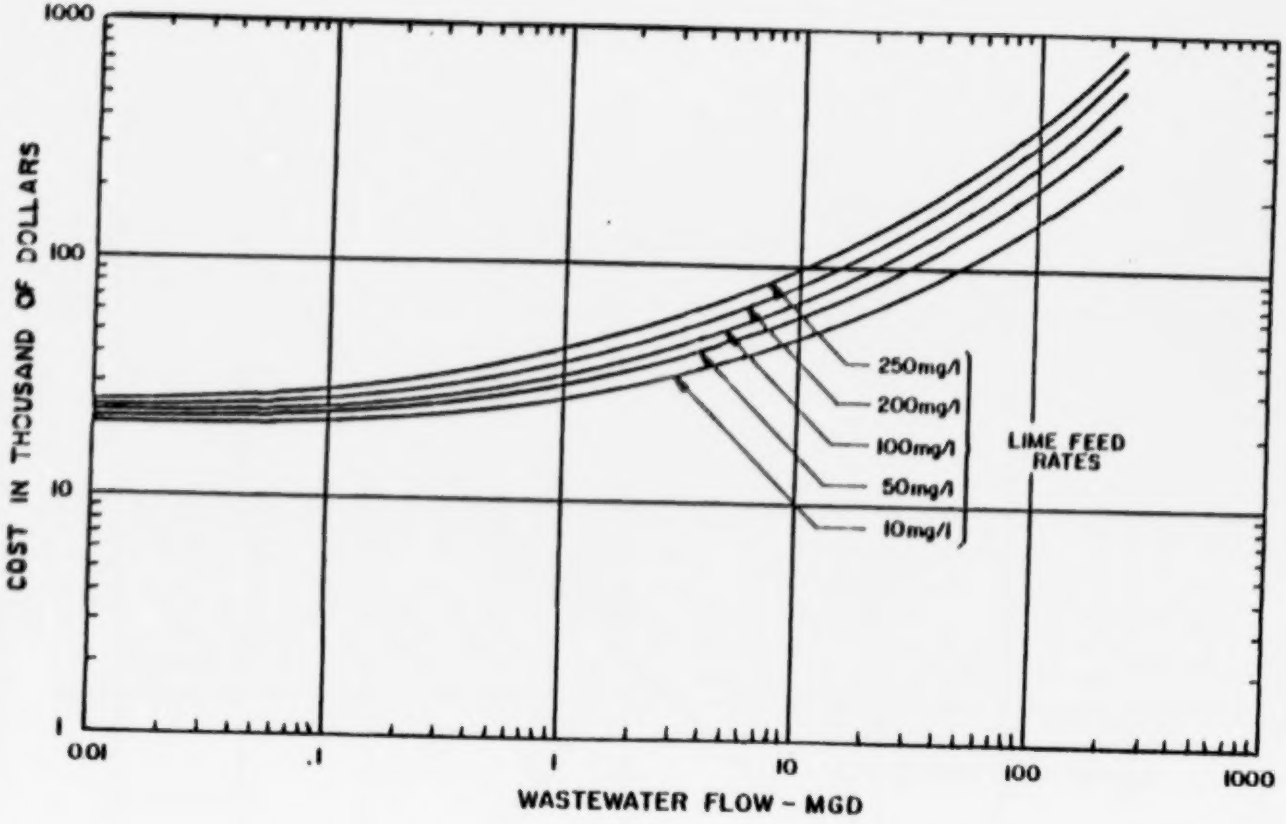


Figure VIII-14

LEVEL 1 MINE WASTEWATER TREATMENT pH ADJUSTMENT
CAPITAL COST CURVES

System Capital Costs for Level 4 Treatment. The equipment and facilities comprising this treatment system are pump station, gravity filters, backwash water storage tank, and control building. A schematic diagram of this system was presented in Figure VIII-4. The capital cost curve was shown in Figure VIII-6. This level of treatment must be applied after either a sedimentation basin alone, or after level 3 treatment. If the total cost for this system is required the costs from Figure VIII-6 should be combined with costs for the appropriate sedimentation basin or the level 3 costs.

Land Requirements

The land requirements for levels 3 and 4 were presented in Figure VIII-7. An insignificant amount of land is required for level 2.

Annual Costs

Level 1. The annual costs for level 1 are composed of sedimentation basin annual costs from Figure VIII-15, lime feeding for pH adjustment from Figure VIII-16 if required and sludge dewatering from Figure VIII-17 if this is installed.

Level 2. The annual costs for level 2, polymer addition, were presented in Figure VIII-8.

Level 3. The annual costs for level 3 were presented in Figure VIII-9.

Level 4. The annual costs for level 4 were presented in Figure VIII-10.

PREPARATION PLANTS AND ASSOCIATED AREAS

Existing Sources

Water discharged from coal preparation plants and their immediate areas originates from two sources: (1) preparation plant process wastewater (PP) and (2) wastewater generated in the vicinity of the plant facilities, from coal storage areas, and from refuse disposal areas (Associated Area Runoff (AA)).

These discharges are disposed of in various methods depending on the specific site under consideration. For instance, the flows could be segregated or commingled. The preparation plant water circuit could be once-through or with partial or total recycle of process wastewaters. Various systems have been costed in an attempt to cover

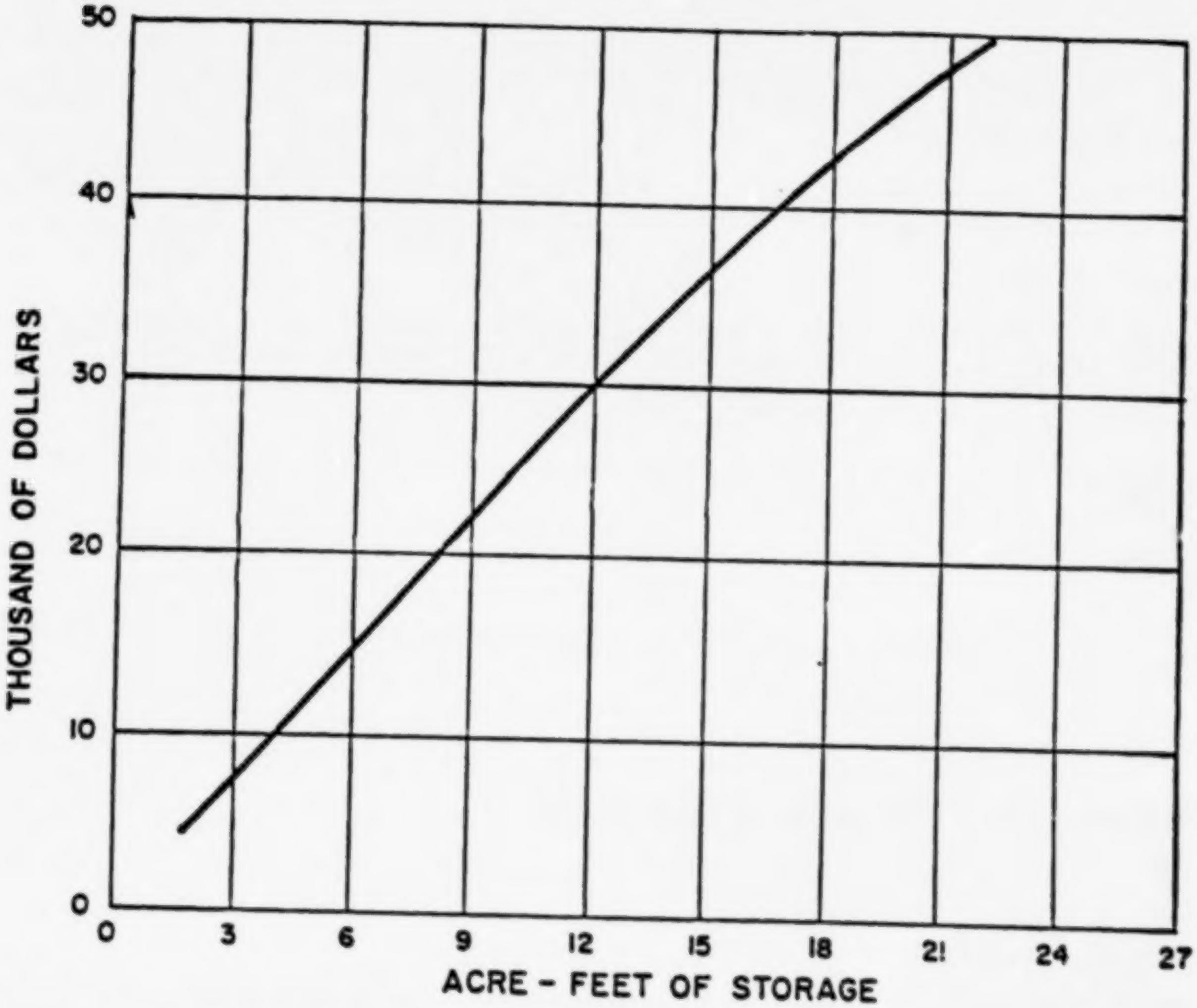


Figure VIII-15
WASTEWATER TREATMENT SEDIMENTATION POND
ANNUAL COST CURVE

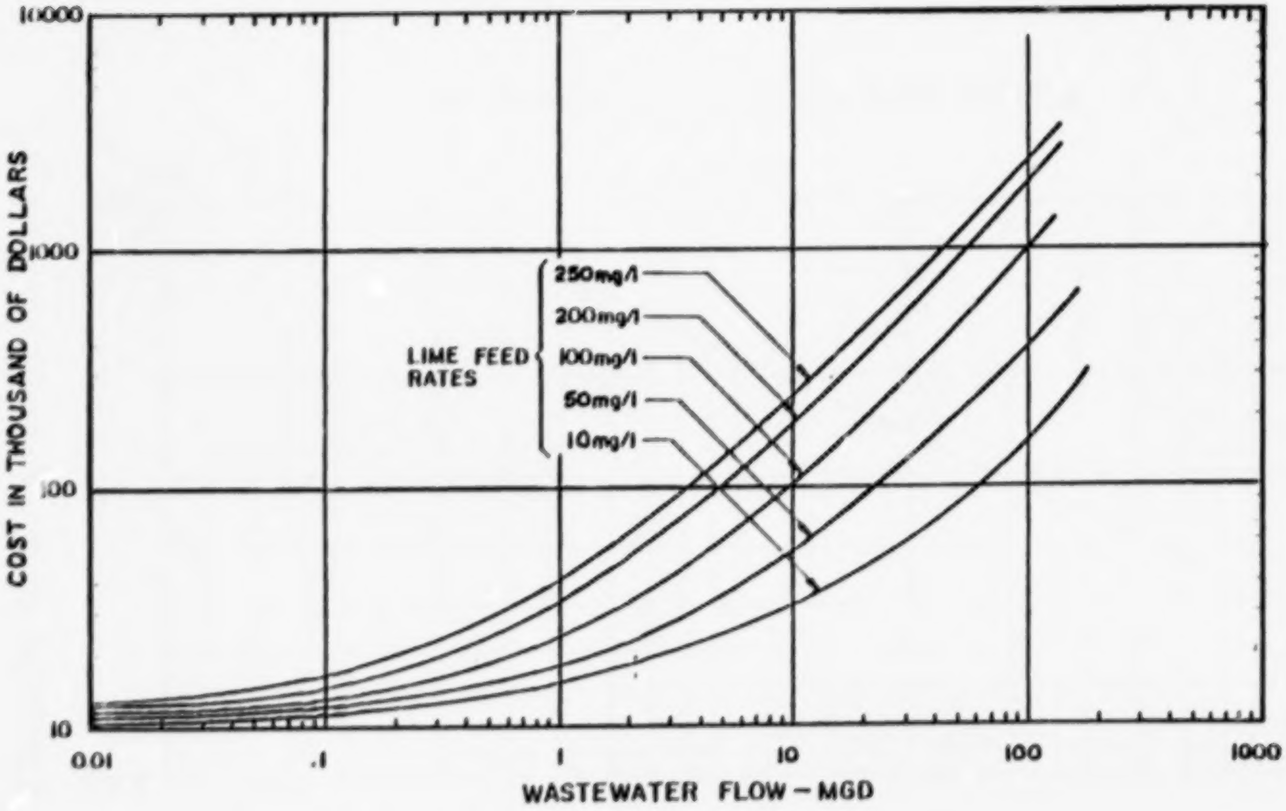


Figure VIII-16

LEVEL 1 MINE WASTEWATER TREATMENT pH ADJUSTMENT
ANNUAL COST CURVES

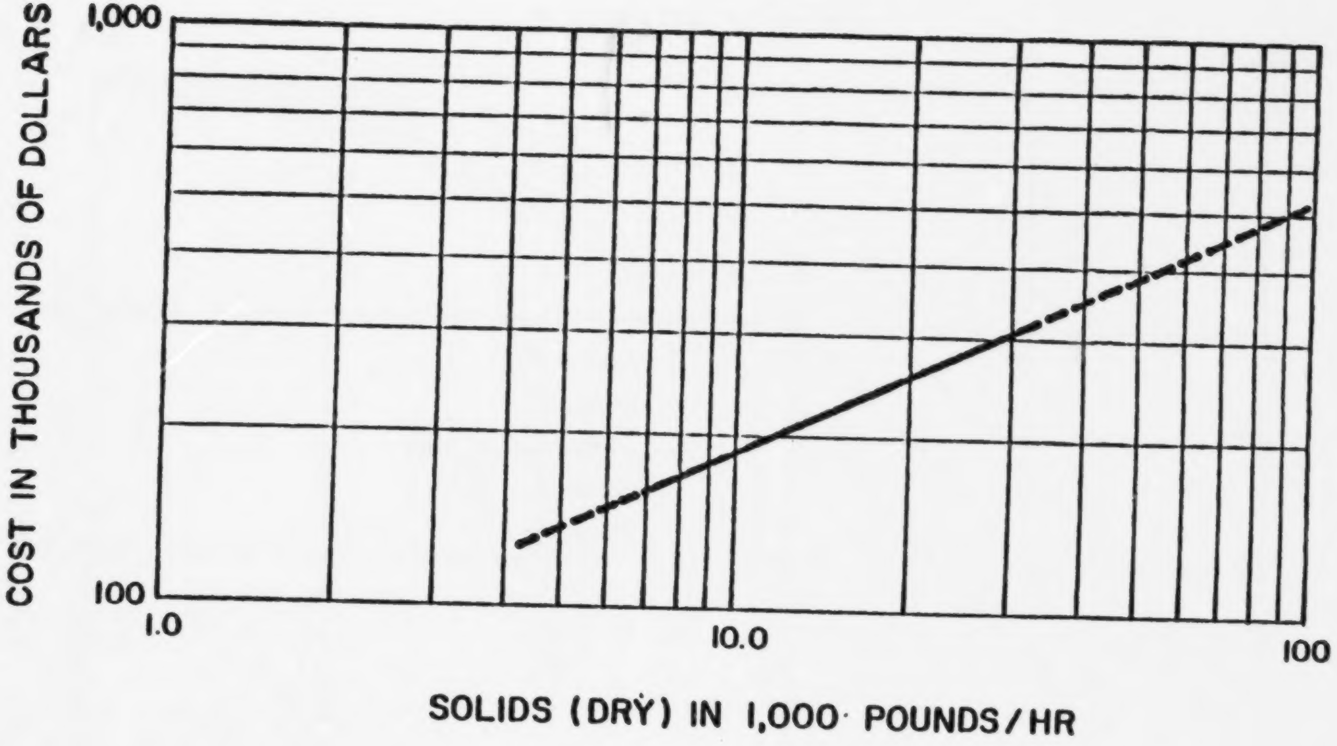


Figure VIII-17
WASTEWATER TREATMENT VACUUM FILTRATION
SLUDGE DEWATERING FACILITIES CAPITAL COST CURVE

each of the water handling options (3). These options and systems are discussed below.

Zero Discharge of Preparation Plant Water Circuit

Three systems were identified for existing sources to achieve total recycle of preparation plant process wastewater (also termed "zero discharge").

System 1. This system, shown in Figure VIII-18, assumes that a pond system is installed, the preparation plant presently has from 0 to 100 percent recycle, and the associated area storm runoff enters the preparation plant water circuit. In this case, the existing sedimentation basin would require dikes to divert the associated area runoff to a new sedimentation pond designed to contain the volume of runoff from a 10-year, 24-hour storm and also diversion of the undisturbed area runoff around the associated area.

System 2. This system assumes that preparation plant wastewater and associated area runoff are segregated for treatment. A clarifier is installed to treat the preparation plant wastewater. Recycle from the clarifier overflow to the preparation plant can vary from 0 to 100 percent. A sedimentation pond is assumed to be in place which receives only associated area runoff and possibly some undisturbed area runoff. Figure VIII-19 is a schematic of this system.

System 3. This system, shown in Figure VIII-20, assumes a clarifier is installed to treat preparation plant wastewater. The clarifier discharge and associated area runoff presently are combined and routed to an existing pond for treatment. Recycle from the pond can vary from 0 to 100 percent. Modifications would include the elimination of the pond from the preparation plant water circuit by installing a new pump station to route 100 percent of the clarifier overflow to the preparation plant. The pond would, however, continue to provide treatment for the associated area runoff.

Allowable Discharge from the Preparation Plant Water Circuit

Since this configuration is currently the option selected by most plants, only one system was identified for costing purposes.

System 4. This scenario assumes an allowable discharge from the preparation plant water circuit. Preparation plant waters may or may not be recycled. Figure VIII-21 is a schematic of this system showing the preparation plant discharge treated first in either a sedimentation basin or a clarifier and then by filtration. Associated area runoff is shown as being treated separately, however, it may be commingled.

Capital Costs

Cost estimates were prepared for the components for each of the preparation plant flow configurations. These costs were then plotted

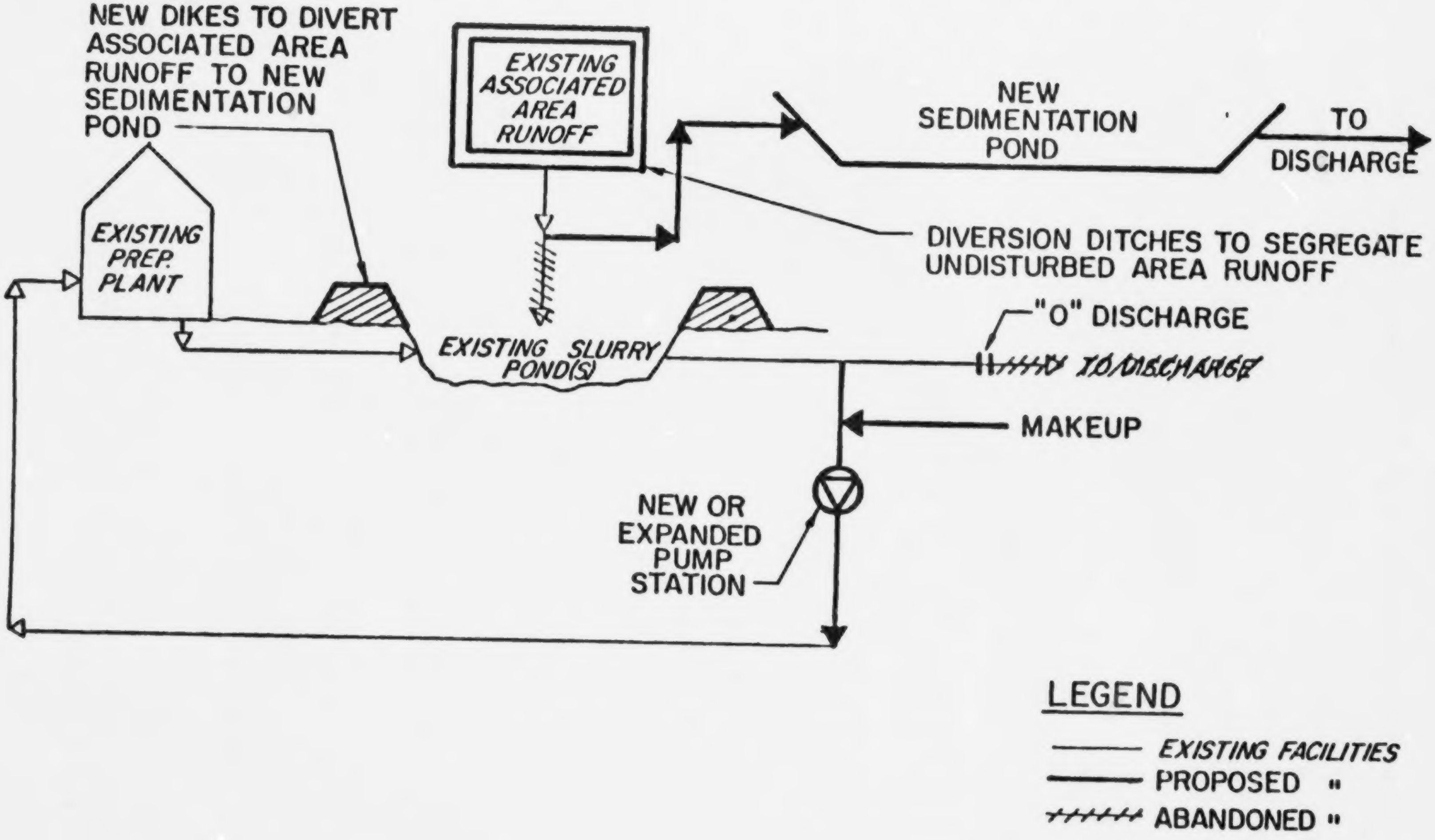

NEW DIKES TO DIVERT ASSOCIATED AREA RUNOFF TO NEW SEDIMENTATION POND
EXISTING ASSOCIATED AREA RUNOFF
NEW SEDIMENTATION POND
TO DISCHARGE
EXISTING PREP. PLANT
DIVERSION DITCHES TO SEGREGATE UNDISTURBED AREA RUNOFF
EXISTING SLURRY POND(S)
"O" DISCHARGE
TO DISCHARGE
MAKEUP
NEW OR EXPANDED PUMP STATION
LEGEND
EXISTING FACILITIES
PROPOSED "
ABANDONED "

Figure VIII-18
EXISTING PREPARATION PLANT - SYSTEM 1 WATER CIRCUITS - ZERO DISCHARGE

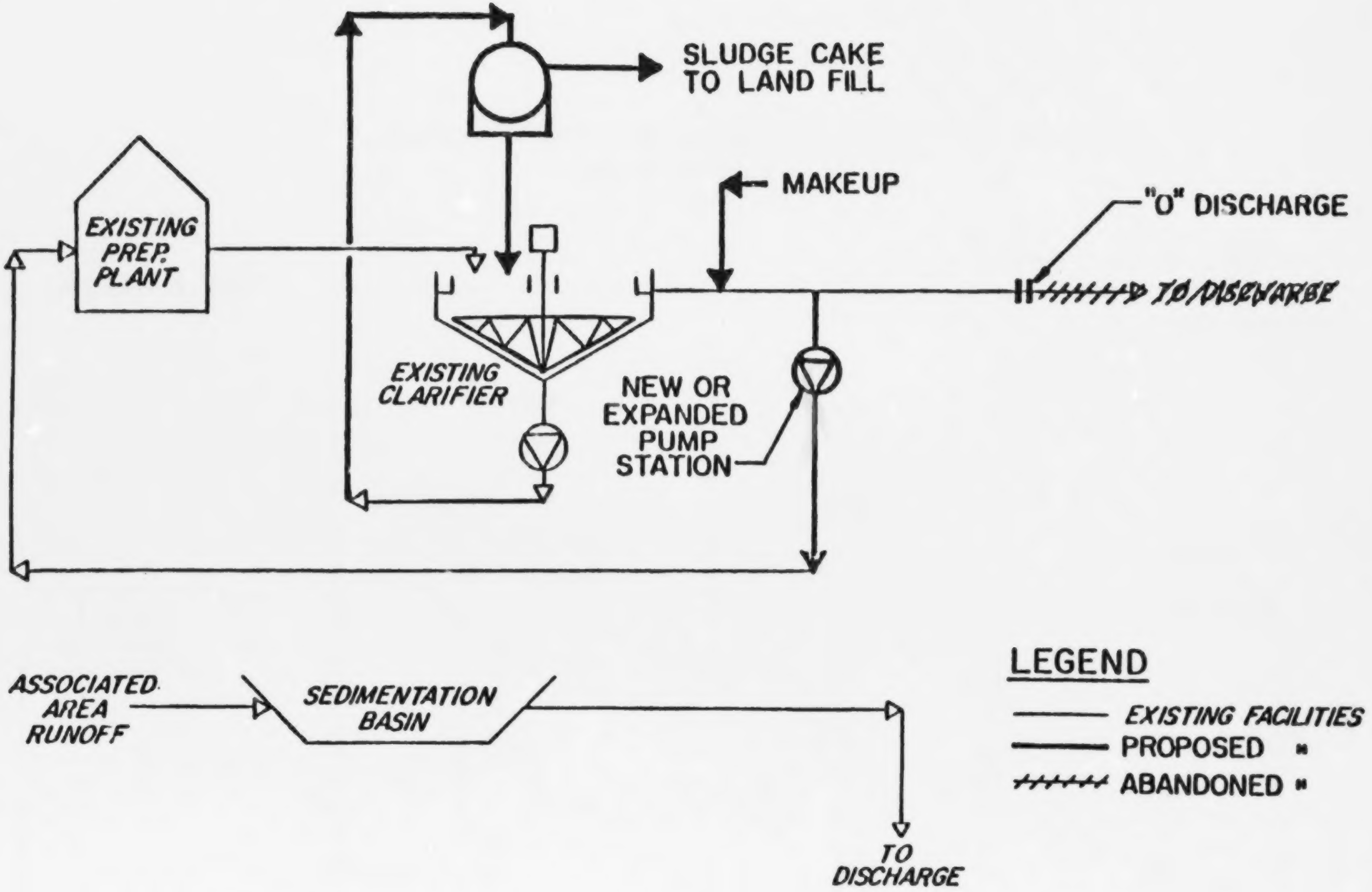


Figure VIII-19

SYSTEM 2 - EXISTING PREPARATION PLANT WATER CIRCUITS

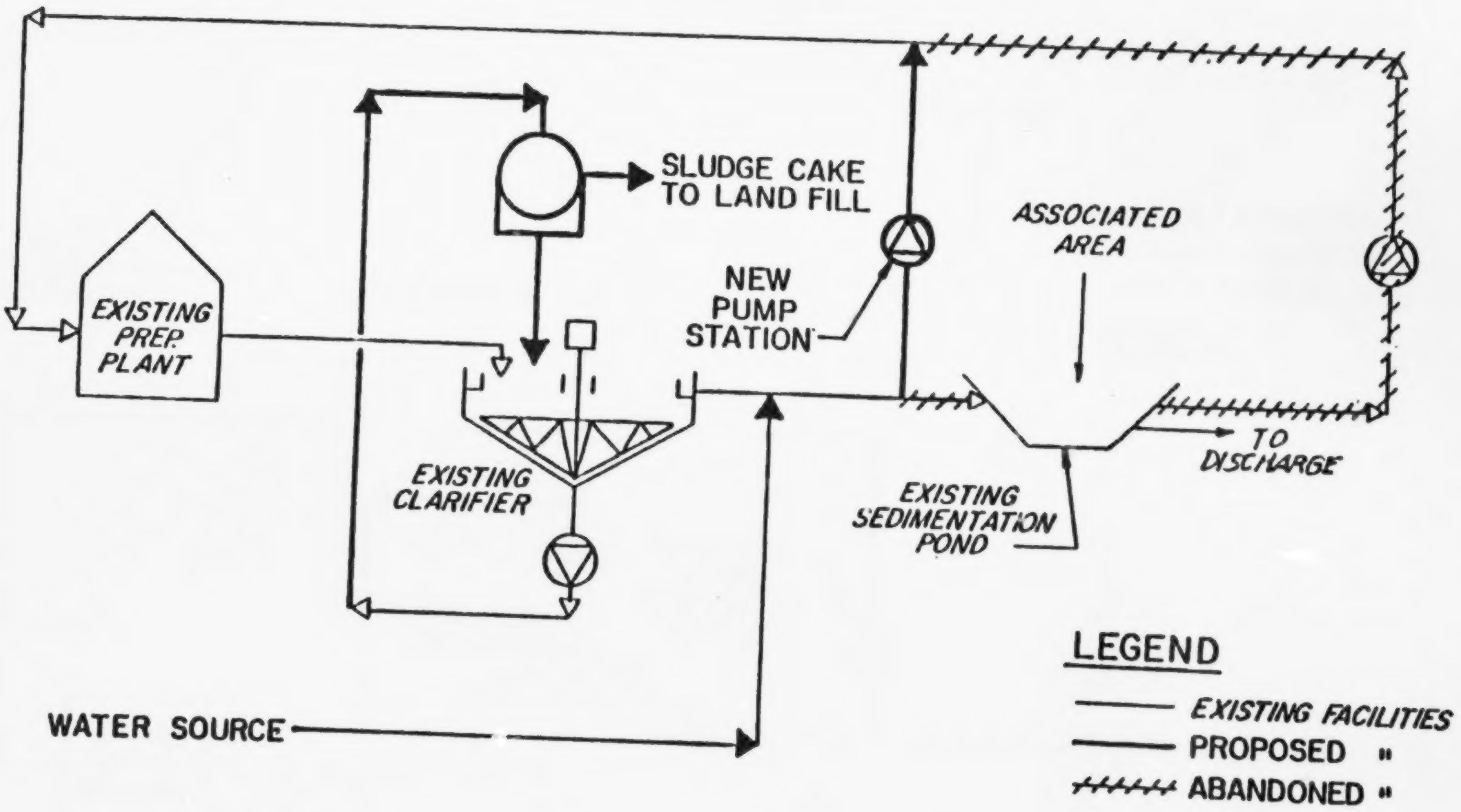


Figure VIII-20
SYSTEM 3 - EXISTING PREPARATION PLANT WATER CIRCUITS

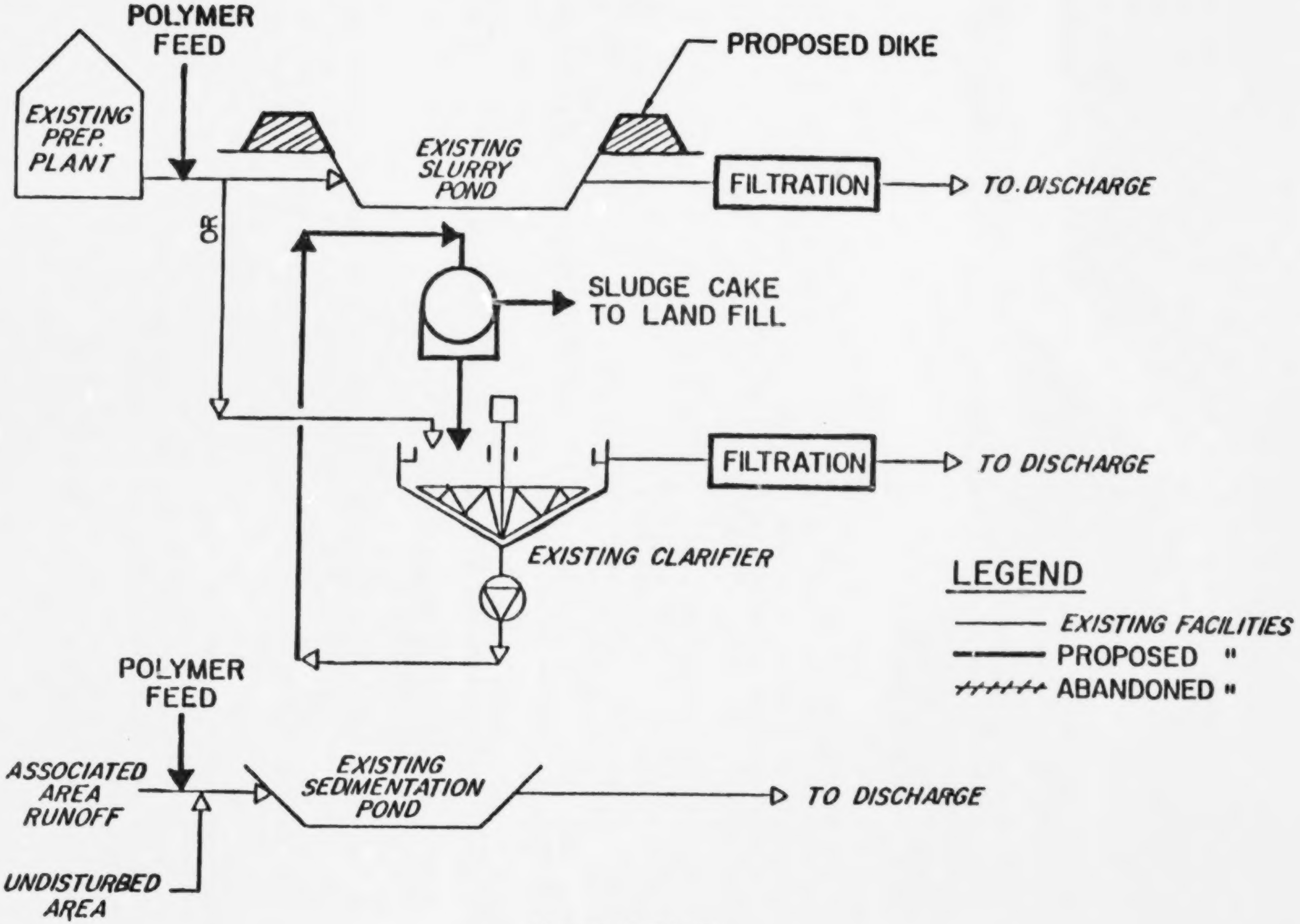


Figure VIII-21

SYSTEM 4 - EXISTING PREPARATION PLANT - ALLOWABLE DISCHARGE with flow rate or, in the case of storm runoff, with runoff volume. The expected cost for each component includes the purchase and installation of all necessary equipment but does not include installation of power lines or access roads assumed to be in place at existing preparation plants, but needed for new sources. Since the total capital cost is very site-specific, the component costs are presented so that if the parameters of a specific site are known the total system can be costed using the appropriate component costs.

System 1. The items that may require costing for this system, depending on the particular site in question, include:

Sedimentation basin-diking,
Associated area drainage ditch construction,
Recycle pump station,
Polymer feed system,
Sedimentation basins.

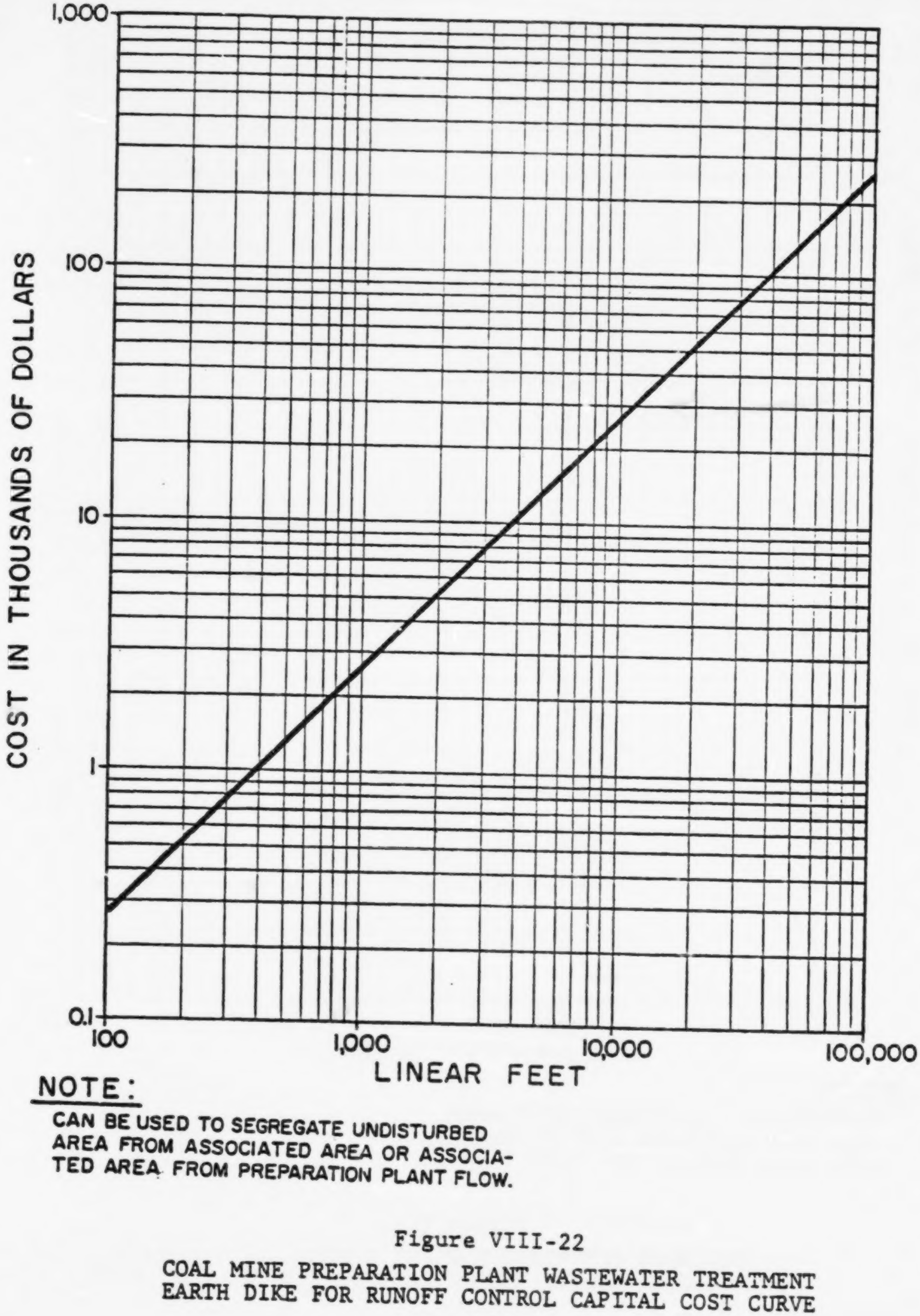
Knowing the size and configuration of the sedimentation basin will allow the determination of the length of diking required. With this known, Figure VIII-22 can be used to determine the cost. The associated area dimensions would then be used to determine the length of drainage ditches required to segregate the undisturbed area runoff from the associated area. Figure VIII-23 is used to determine the cost of the ditches required. Figure VIII-13 is used to determine the cost of the sedimentation basin required to serve the associated area and Figure VIII-24 is used to determine the cost of a new recycle pump station. If there is a flow from the associated area during dry weather, a polymer addition system may be required so that the effluent will meet guidelines. A cost of $30,000 is estimated for flows less than 750,000 gpd and $40,000 for flow rates greater than 750,000 gpd, including an enclosure.

System 2. The items that may require costing for this system, depending on the particular site in question, include:

Clarifier underflow dewatering
Recycle pump station

It is assumed that the existing associated area sedimentation basin will not require augmentation. Figure VIII-24 is again used to determine the cost of pumping facilities. The sludge dewatering capital cost can be determined from Figure VIII-17. The vacuum filter loading rate (based on vendor design criteria) is 50 pounds/hr/ft^2. Assuming the flow rate and slurry concentration at a particular preparation plant is known, the proper size filter can then be determined. As an example, for a vacuum filter influent suspended solids concentration of 100,000 mg/l (10 percent), and a flow of 250 gpm, the solids level in pounds per hour would be calculated using the following formula:

$$S = \frac{C \times F \times D \times T}{10^6}$$

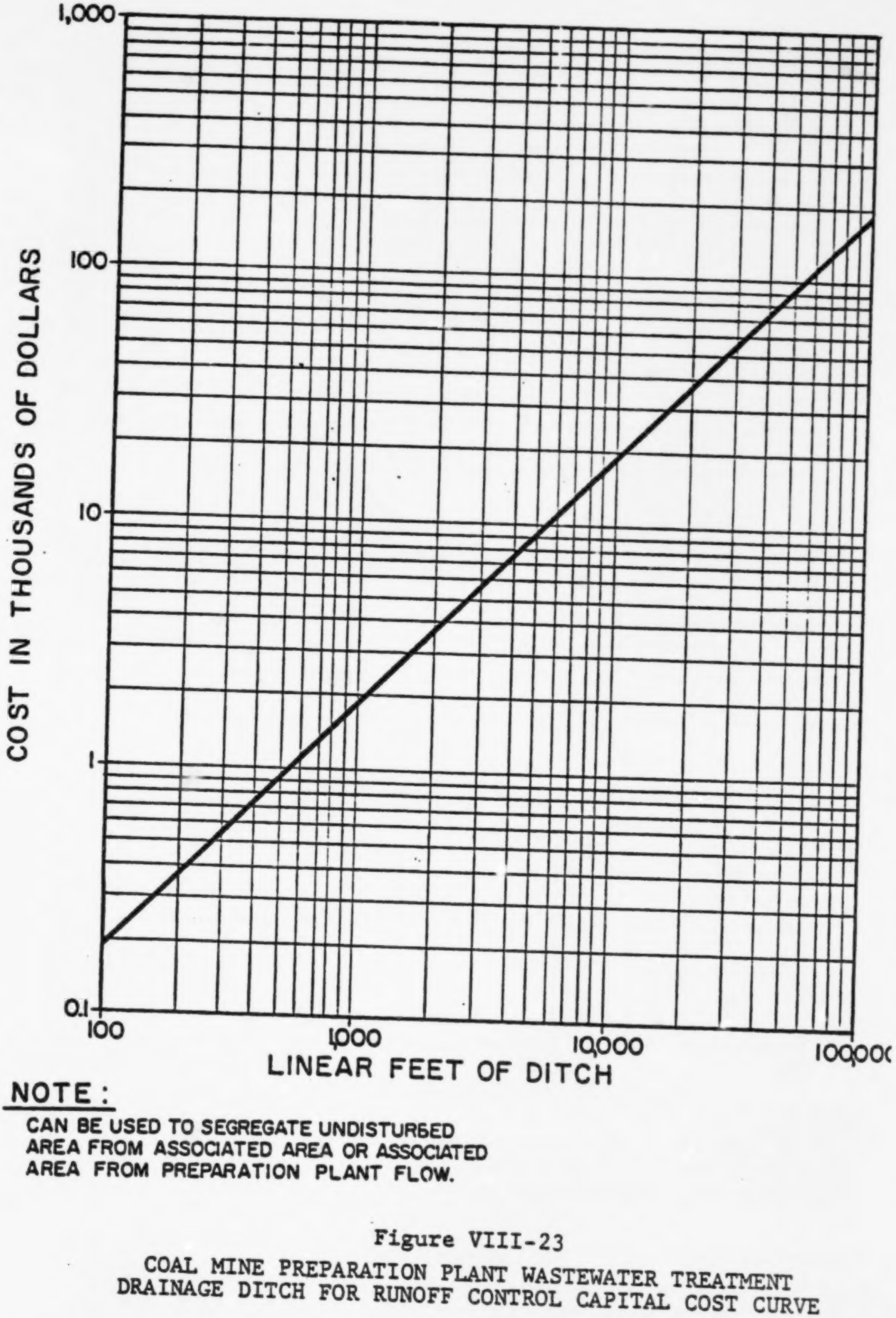


NOTE:

CAN BE USED TO SEGREGATE UNDISTURBED AREA FROM ASSOCIATED AREA OR ASSOCIATED AREA FROM PREPARATION PLANT FLOW.

Figure VIII-22

COAL MINE PREPARATION PLANT WASTEWATER TREATMENT EARTH DIKE FOR RUNOFF CONTROL CAPITAL COST CURVE



NOTE:

CAN BE USED TO SEGREGATE UNDISTURBED
AREA FROM ASSOCIATED AREA OR ASSOCIATED
AREA FROM PREPARATION PLANT FLOW.

Figure VIII-23

COAL MINE PREPARATION PLANT WASTEWATER TREATMENT
DRAINAGE DITCH FOR RUNOFF CONTROL CAPITAL COST CURVE

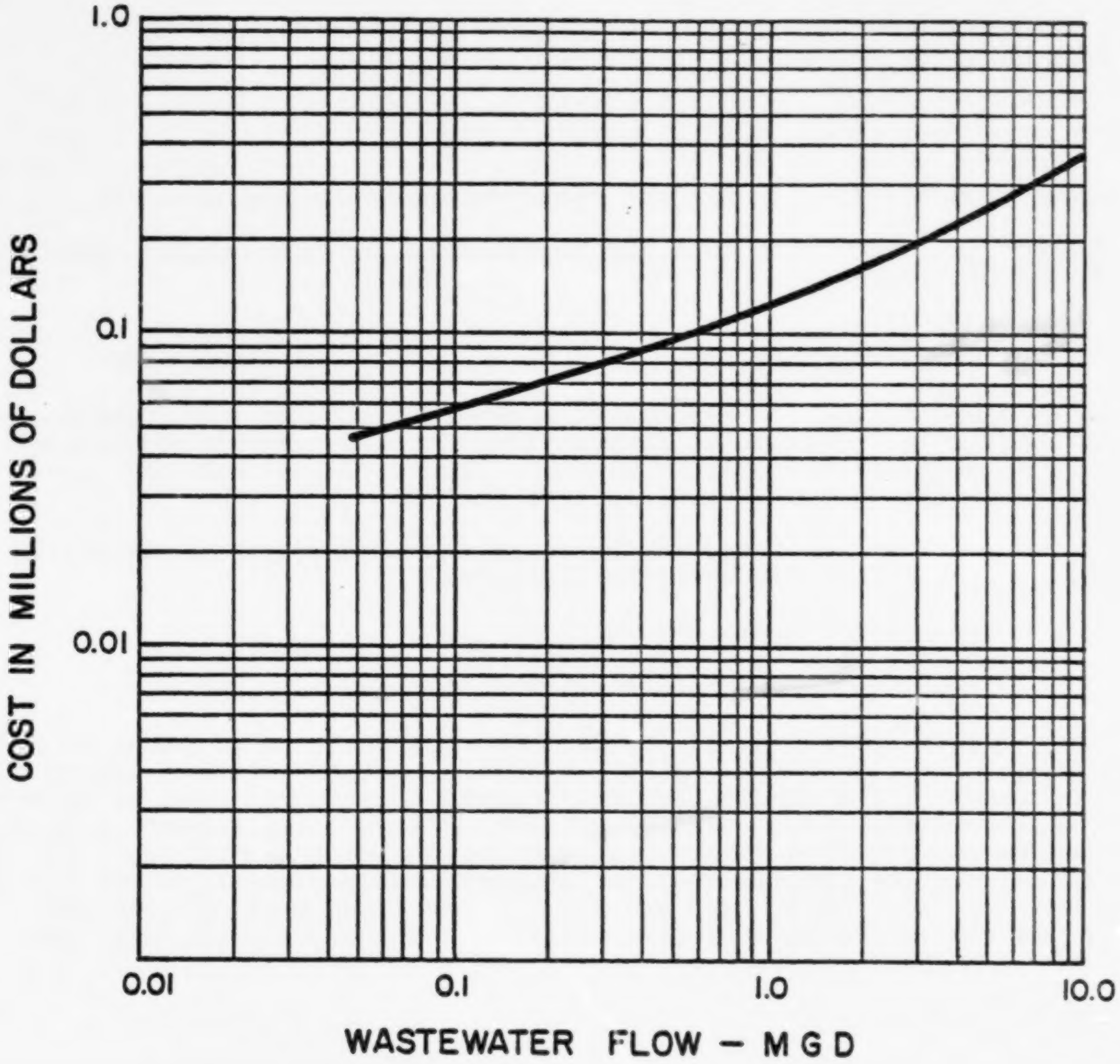


Figure VIII-24
COAL MINE PREPARATION PLANT WASTEWATER TREATMENT
RECYCLE/MAKE-UP WATER PUMPING FACILITY CAPITAL COST CURVE

where C = concentration of suspended solids in mg/l

F = flow in gpm

D = 8.34 lbs/gallon

T = time = 60 minutes.

For the example stated:

S = 12,510 lbs per hour.

Using Figure VIII-17, the cost would be approximately $250,000.

System 3. The items that may be required for this system, depending on the particular site in question, include:

Sludge dewatering
Recycle pump station

It is assumed that the associated area sedimentation basin design will not require augmentation. Figure VIII-17 can be used to determine the cost of dewatering clarifier sludge. Figure VIII-24 can be used to determine the cost of a recycle pump station.

System 4. The items that may be required for the system, depending on the particular site in question, include:

Sedimentation basin-diking
Sludge dewatering
Polymer feed and granular media filtration.

This system assumes an allowable discharge from the preparation plant without recycle using either existing sedimentation basins or clarifiers. The sludge dewatering cost, if required, can be obtained from Figure VIII-17. In order to meet effluent limitations, a polymer feed may be required before the preparation plant slurry pond or the clarifier. The capital cost for polymer feed equipment is $30,000 for flows up to 750,000 gpd and $40,000 for flows over 750,000 gpd. If filtration is required to meet effluent limitations its cost can be found in Figure VIII-6.

Annual Costs

Since the components for the various systems described above and the annual costs to operate and amortize these components are the same, the annual costs are presented only once. Once the need for a component in a particular system is determined, the annual cost is derived from the following Figures: VIII-25; Annual Costs of Dikes and Ditches, VIII-26; Annual Costs of Recycle Pump Station, VIII-27 Annual Costs of Sludge Dewatering Facilities, VIII-15; Annual Costs of Sedimentation Ponds, VIII-28; Annual Costs of Clarifier and Pump

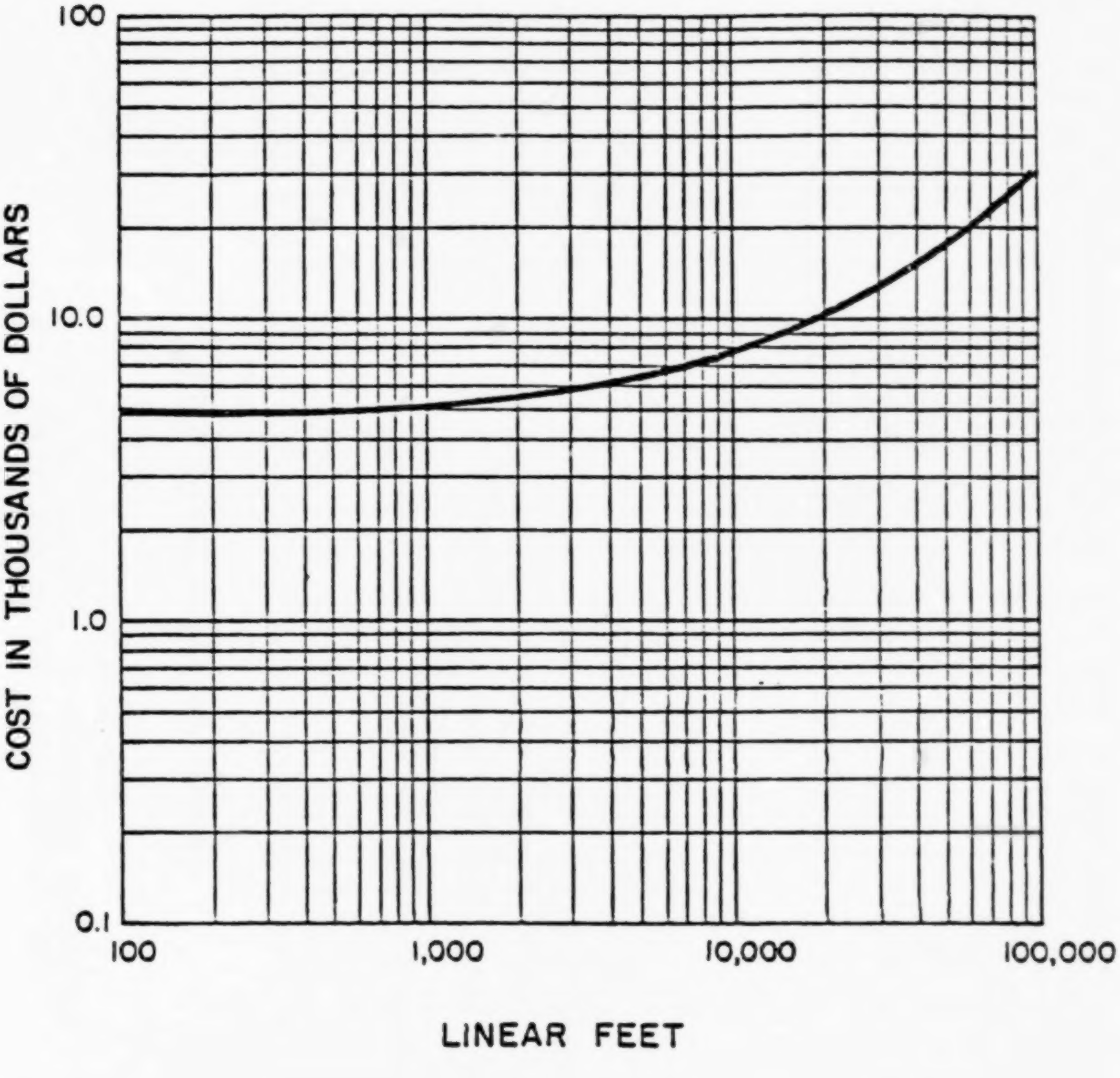


Figure VIII-25
WASTEWATER TREATMENT EARTH DIKE/DRAINAGE DITCH
FOR RUNOFF CONTROL ANNUAL COST CURVE

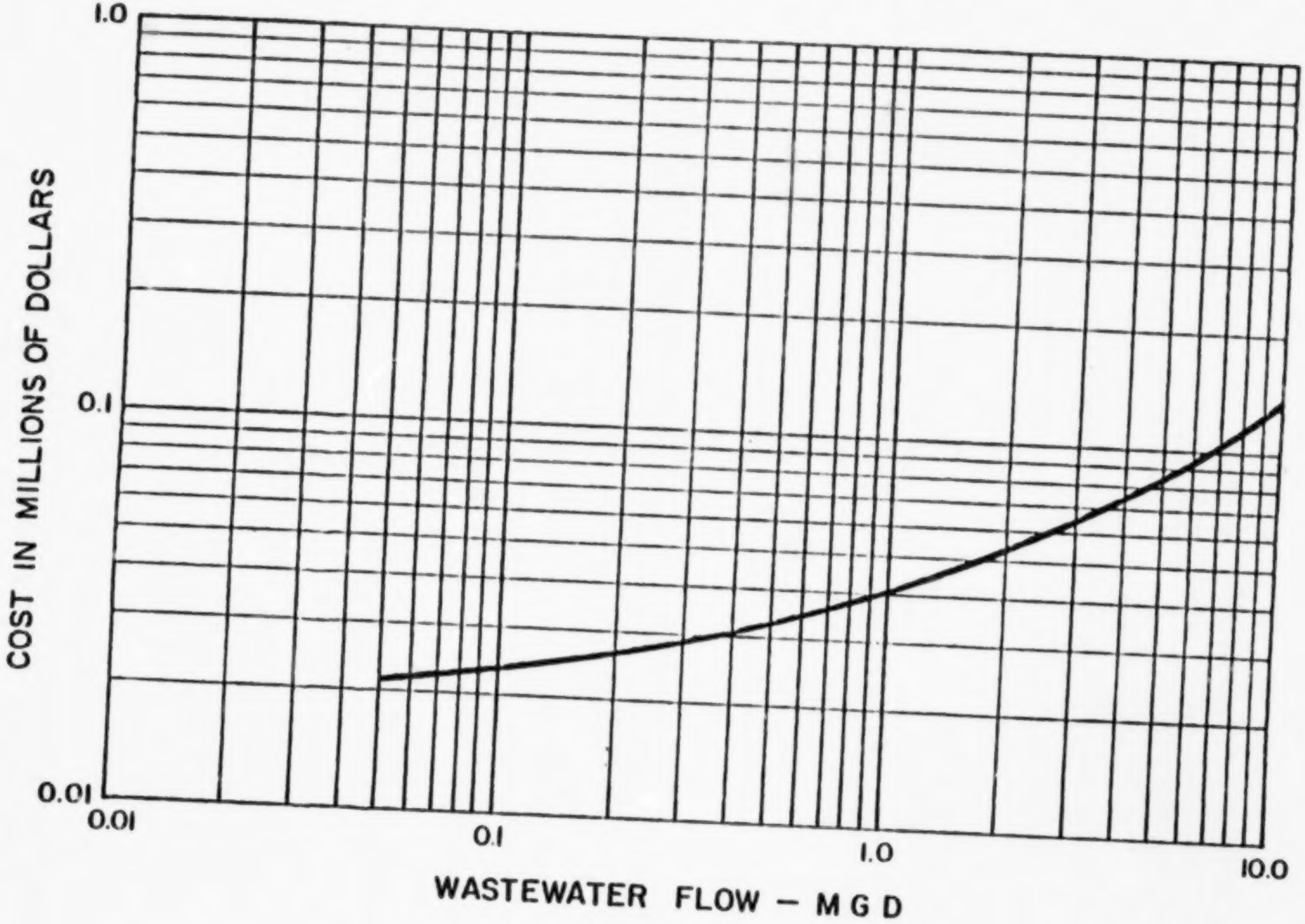


Figure VIII-26

WASTEWATER TREATMENT RECYCLE/MAKE-UP WATER
PUMPING FACILITIES ANNUAL COST CURVE

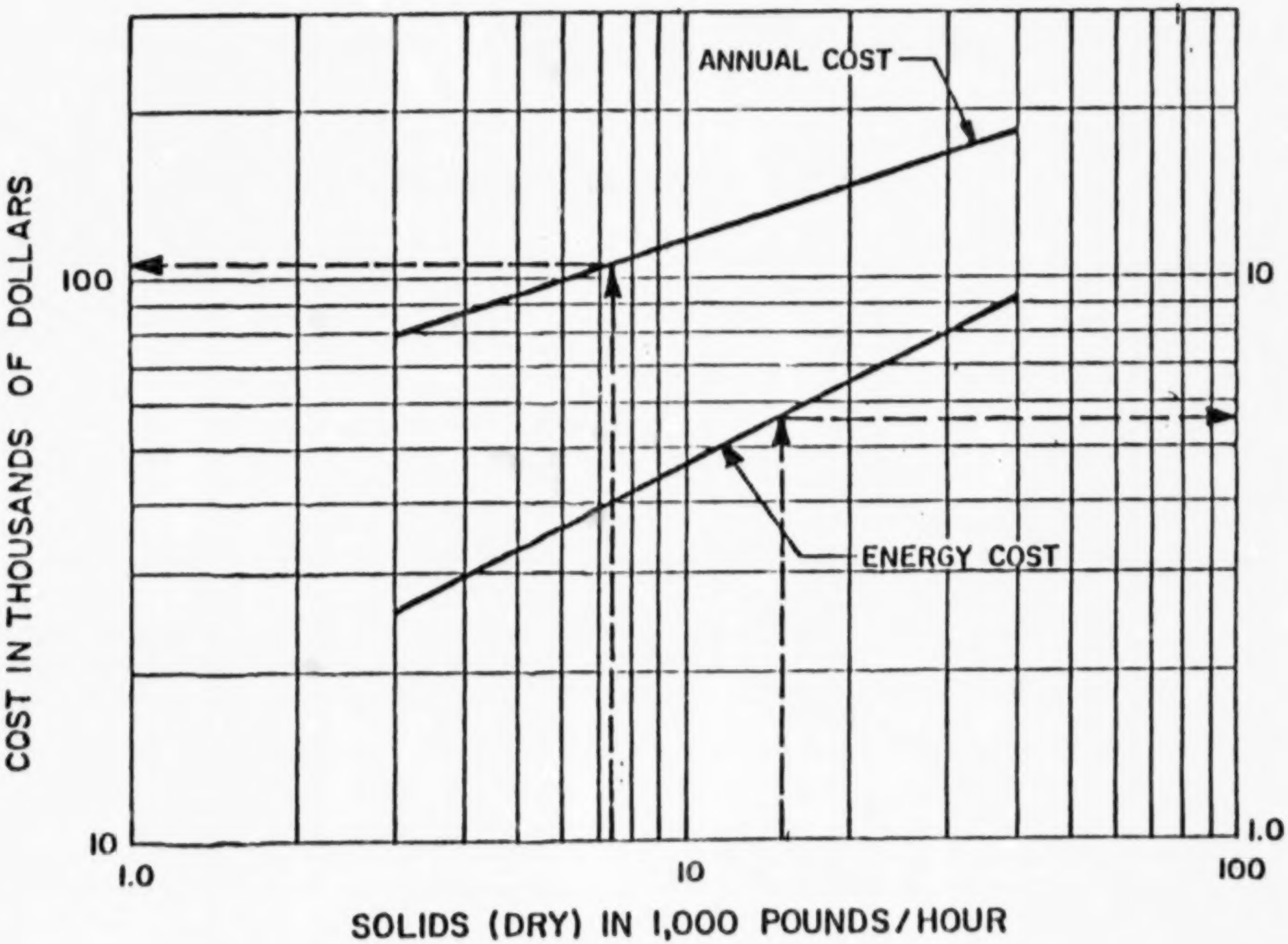


Figure VIII-27
WASTEWATER TREATMENT SLUDGE DEWATERING FACILITIES
ANNUAL COST CURVE

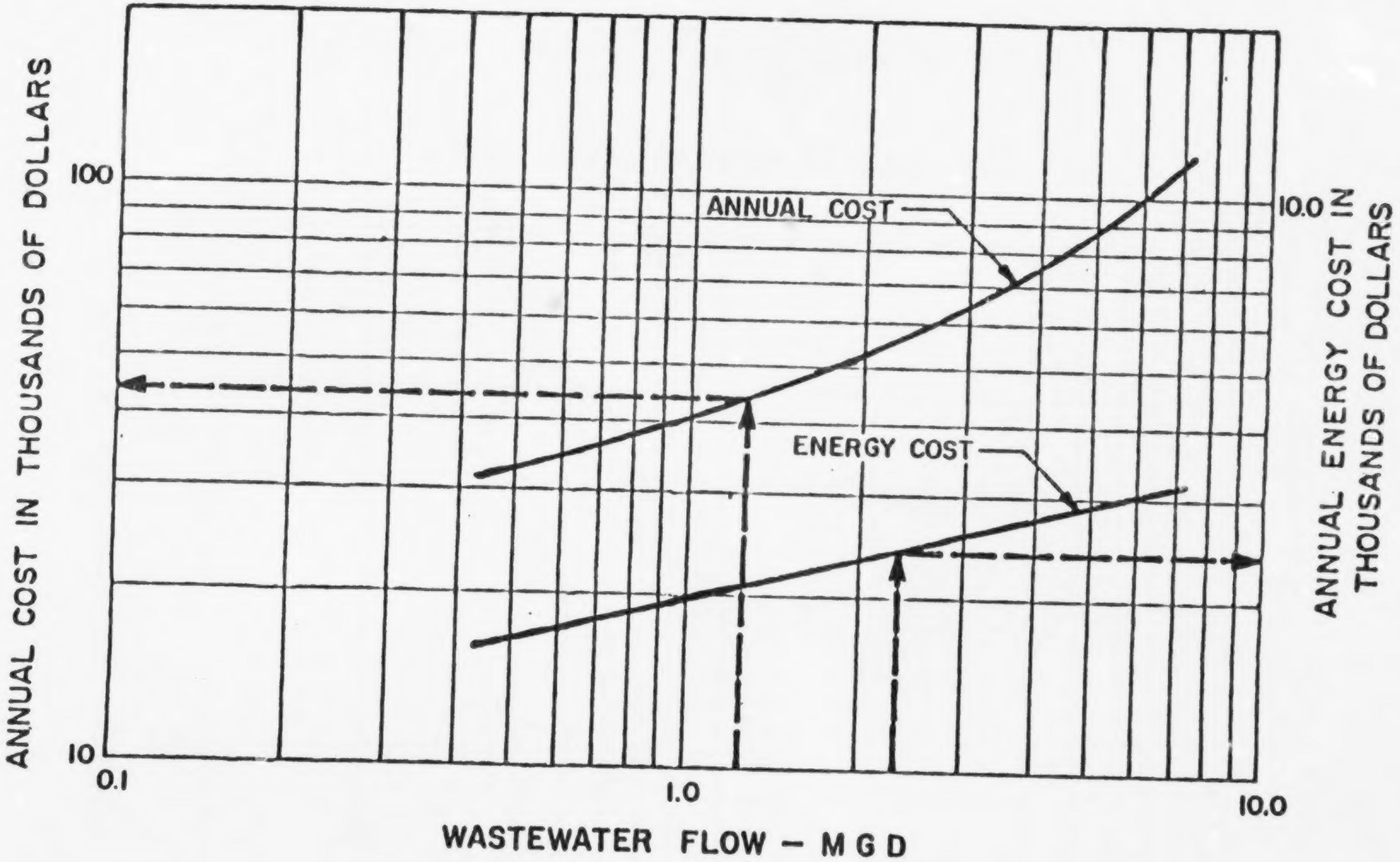


Figure VIII-28
WASTEWATER TREATMENT CLARIFIER AND PUMP STATION
ANNUAL COST CURVE

Station. All the component annual costs are additive for a given system.

New Sources

Zero Discharge from Preparation Plant Water Circuit

System 1. This system assumes a new source using a pond to treat the preparation plant discharge prior to 100 percent recycle. A separate pond designed to contain the runoff from a 10-year, 24-hour storm would be used for associated area runoff. The associated area and pond would be ditched to divert an undisturbed area runoff from associated area runoff. Figure VIII-29 is a schematic of this system.

System 2. This system assumes a new source using a clarifier to treat the preparation plant discharge prior to 100 percent recycle. A separate pond designed to contain the runoff from a 10-year, 24-hour storm would be used for associated area runoff. The associated area and pond would be ditched to divert undisturbed area runoff from associated area runoff. Figure VIII-30 is a schematic of this system.

Capital Costs

System 1. This system, as shown in Figure VIII-29, is applied to new sites where all treatment facilities are constructed when the preparation plant is constructed. A slurry pond for the preparation plant wastewater would be installed and a pump station for 100 percent recycle of the treated water required. Associated area runoff would be segregated from the undisturbed area. The items required for this system include Figures: VIII-13 & VIII-22; Preparation Plant Slurry Pond with Dikes, VIII-24; Recycle pump Station, VIII-23; Associated Area Segregation by Ditch and VIII-13; Pond for Associated Area Runoff. The figure numbers next to the items can be used to determine the capital costs.

System 2. This system, as shown in Figure VIII-30, is applied to new sites when a clarifier is used to treat the preparation plant discharge. The items required for this system include Figures: VIII-31; Clarifier, VIII-17; Sludge Dewatering, VIII-24; Recycle Pump Station, VIII-23; Associated Area Segregation from Undisturbed Area by Ditch, and VIII-13 and VIII-22; Pond Associated Area Runoff. The figure numbers next to the items can be used to determine the capital costs.

Annual Costs

For both new source systems, the annual costs can be derived from the same annual cost curves presented for existing sources.

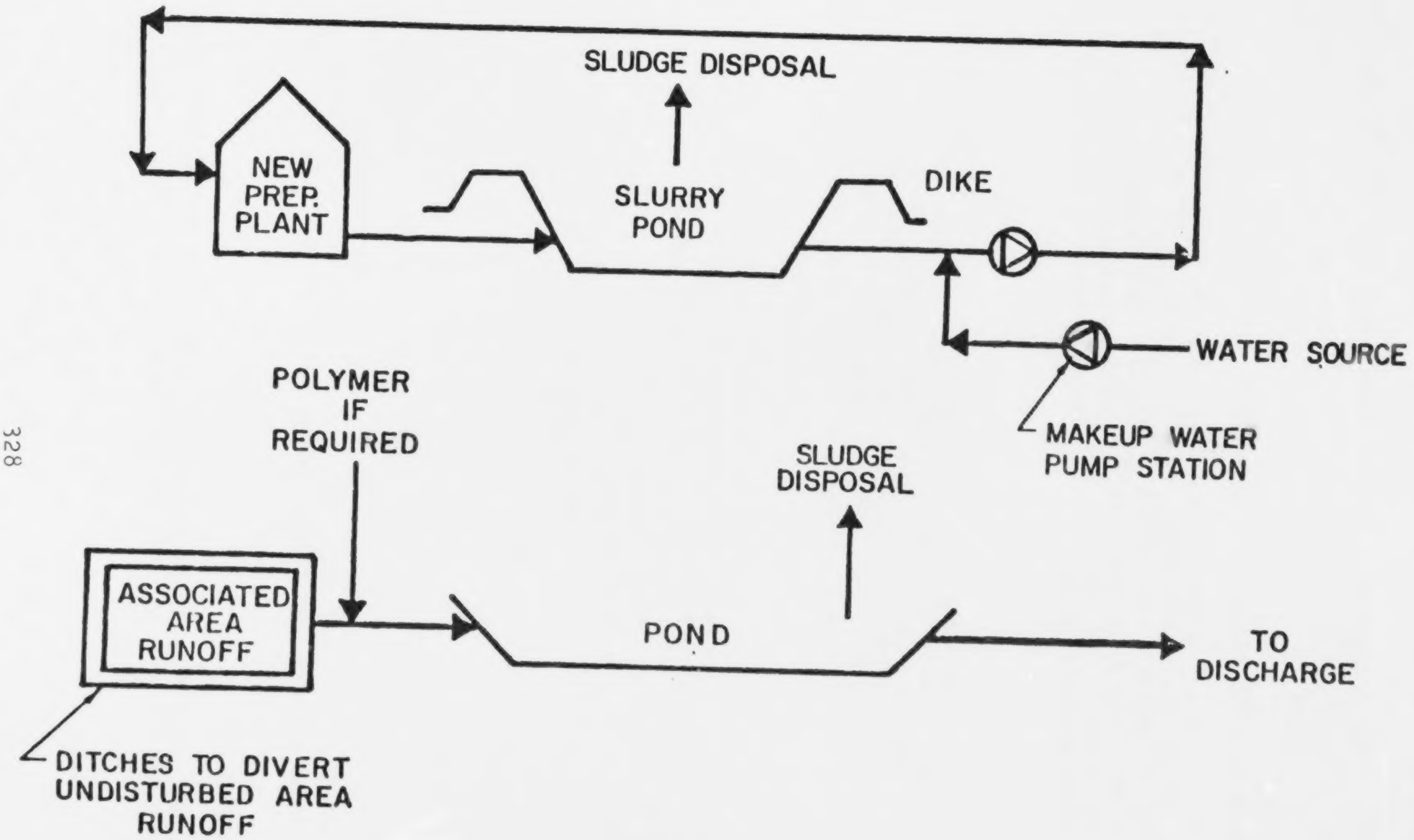


Figure VIII-29

SYSTEM 1 - NEW SOURCE WATER CIRCUITS

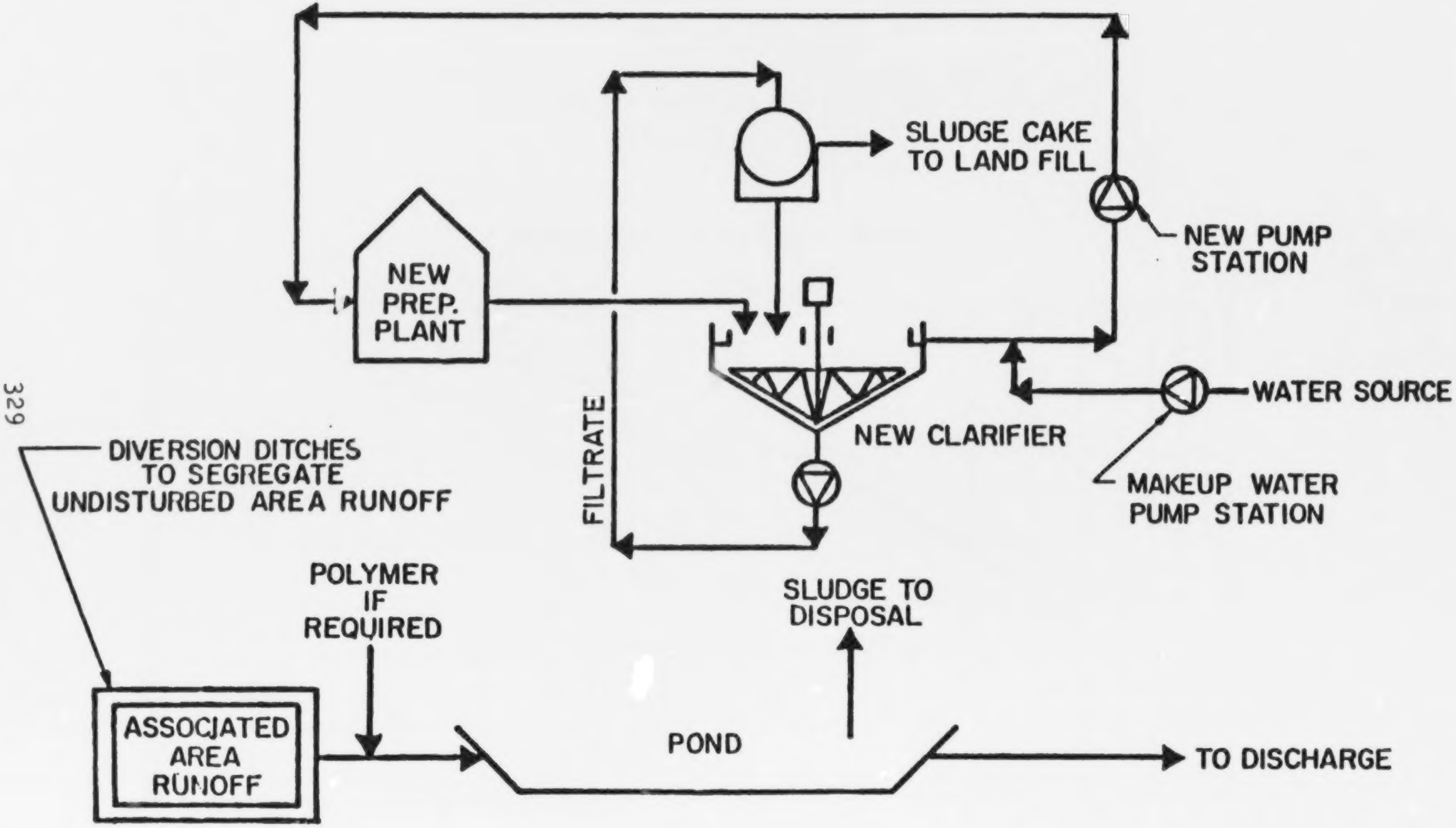


Figure VIII - 30

SYSTEM 2 - NEW SOURCE WATER CIRCUITS

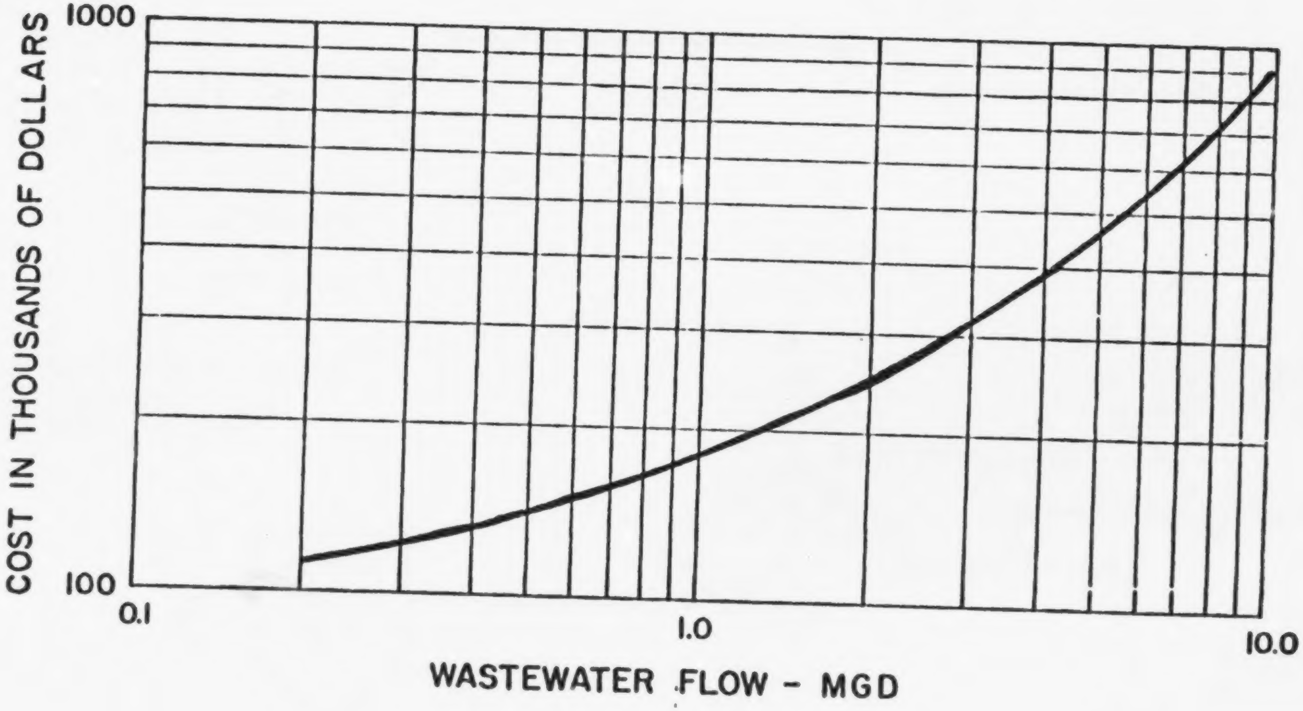


Figure VIII-31

WASTEWATER TREATMENT CLARIFIER
AND PUMPING FACILITIES CAPITAL COST CURVE

POST MINING DISCHARGES

Operation and maintenance costs to treat post mining discharges through bond release are presented in this section. (Note: this treatment is already required by OSM.)

General Assumptions Used

In determining the treatment costs, five assumptions were made:

1. No capital charges are included. It is assumed facilities are fully depreciated by the time of mine closure.

2. No "typical" pond size could be assumed. Ponds range from "no pond" to 21 acre-feet in storage.

3. A "typical" lime dosage is 300 mg/l.

4. Operation and maintenance and energy costs for lime feeding are not sensitive to lime dosage rates are assumed constant.

5. Sludge pumping energy costs are less than five percent of the total operation and maintenance costs.

Therefore, energy costs for varying sludge rates are masked by the total operation and maintenance costs.

Reclamation Areas

These costs apply only to surface mines. The costs include sedimentation structures for treating the runoff from areas under reclamation through release from the applicable reclamation bond. For this subcategory, treatment is for the control of settleable solids and pH.

Assumptions

In determining the treatment costs, two assumptions were necessary:

1. Since limitations for active mining are based on treatment pond technology and facilities can leave the pond in-place, no capital costs result from these requirements.

2. Lime for pH control should not be required for discharge systems covered in the reclamation phase since no acid wastewater should be formed at these facilities.

Again, this has been verified by an Agency study of reclamation areas.

Operation and Maintenance Costs

The costs associated with areas under reclamation include operation and maintenance costs for sedimentation ponds and maintenance costs for runoff control with earth dikes or drainage ditches. The cost curves for these areas are identical to figures previously presented, but are repeated here for convenience. Figure VIII-32 presents operation and maintenance costs for sedimentation ponds. The capital cost of the pond was found in Figure VIII-13. The maintenance costs for runoff control with earth dikes or drainage ditches are given in Figure VIII-33. Supporting information and assumptions for developing these figures may be obtained in Appendix A to the Proposed Coal Mining Development Document (EPA 440/1-81/057-b).

Alkaline Underground Mines

Only settling ponds are considered for costing. No clarifiers have been included because few alkaline deep mines employ clarifiers for wastewater treatment. The annual operation and maintenance cost curve for wastewater treatment with settling ponds was presented in Figure VIII-32. The annual maintenance cost curve for earth dike or drainage ditch runoff control was illustrated in Figure VIII-33. Supporting information and assumptions for developing these figures may be found in Appendix A to the Proposed Coal Mining Development Document.

Acid Underground Mines

Two treatment systems are considered for costing. The first system includes settling ponds, lime addition equipment, and aeration equipment. The second system includes clarifiers, lime addition equipment, and aeration equipment.

Costs Associated with Both Settling Pond and Clarifier.

The annual costs associated with both systems may be obtained from Figures VIII-34, VIII-35, and VIII-36. Included in the cost curves of Figure VIII-36 is the cost of hydrated lime at $65 per ton. Supporting information and assumptions for developing these figures may be found in Appendix A.

Costs Associated Only with the Settling Pond System.

Operation and maintenance costs were illustrated in Figures VIII-32 and VIII-33. The total operation and maintenance costs for the sedimentation pond system (including sedimentation ponds, lime addition and aeration) are determined by adding the costs from Figures VIII-32 and VIII-33 to the costs obtained from Figures VIII-34, VIII-35, and VIII-36.

Cost Associated Only with the Clarifier System.

The clarifier and sludge pumping operation and maintenance costs are presented in Figure VIII-37. To obtain the total operation and maintenance costs for the clarifier system (including clarifiers, lime

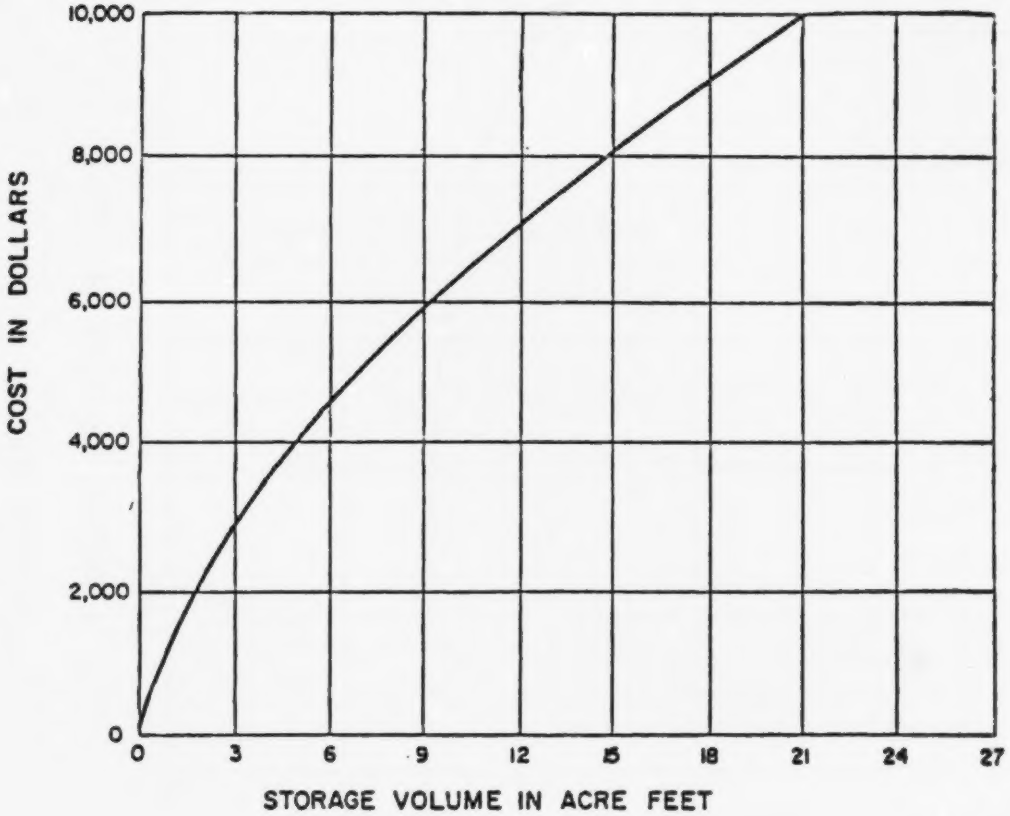


Figure VIII-32

SEDIMENTATION POND OPERATION AND MAINTENANCE ANNUAL COST CURVE FOR POST MINING DISCHARGES

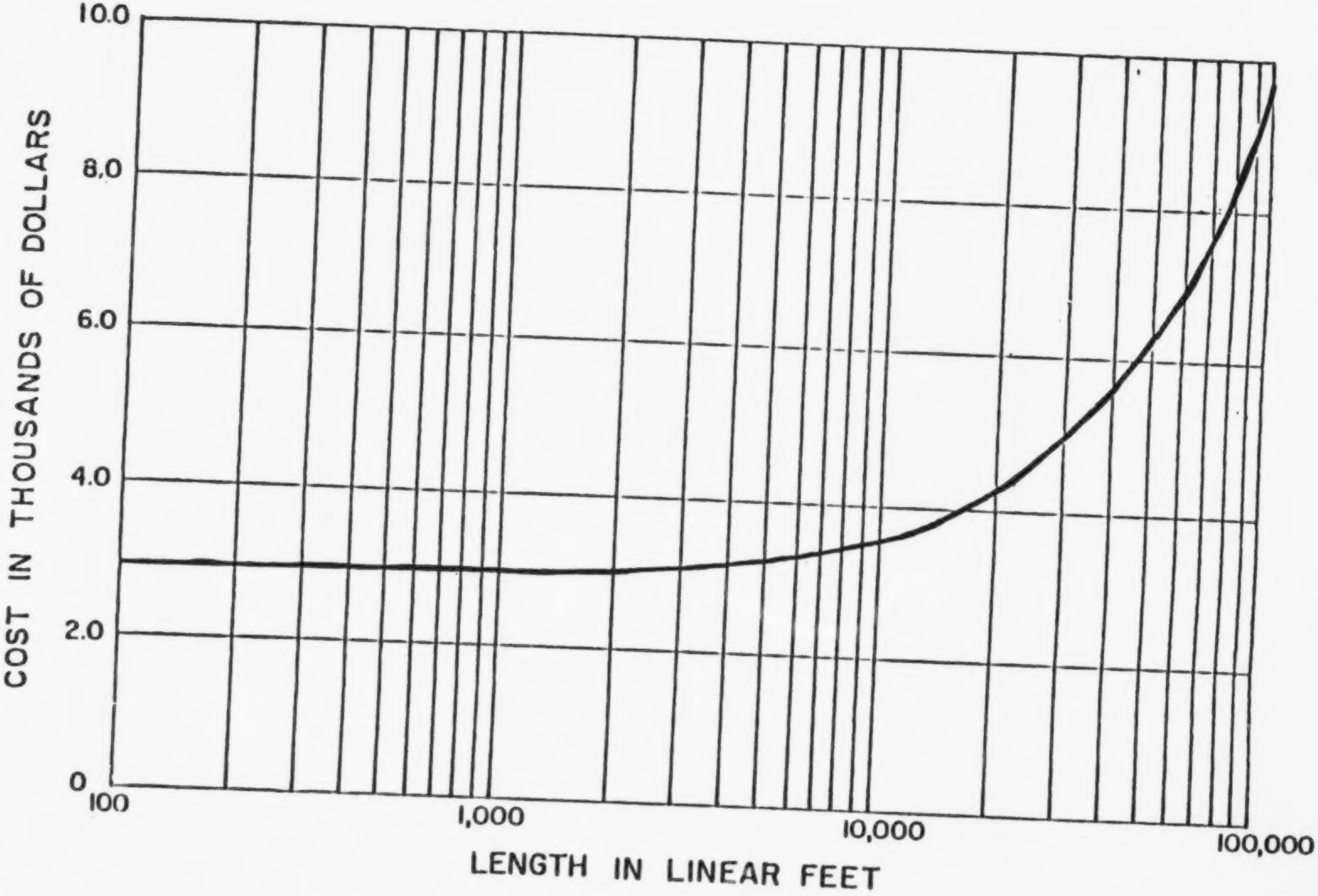


Figure VIII-33

ANNUAL MAINTENANCE COST CURVE FOR EARTH DIKE/DRAINAGE DITCH
RUNOFF CONTROL FOR POST MINING DISCHARGES

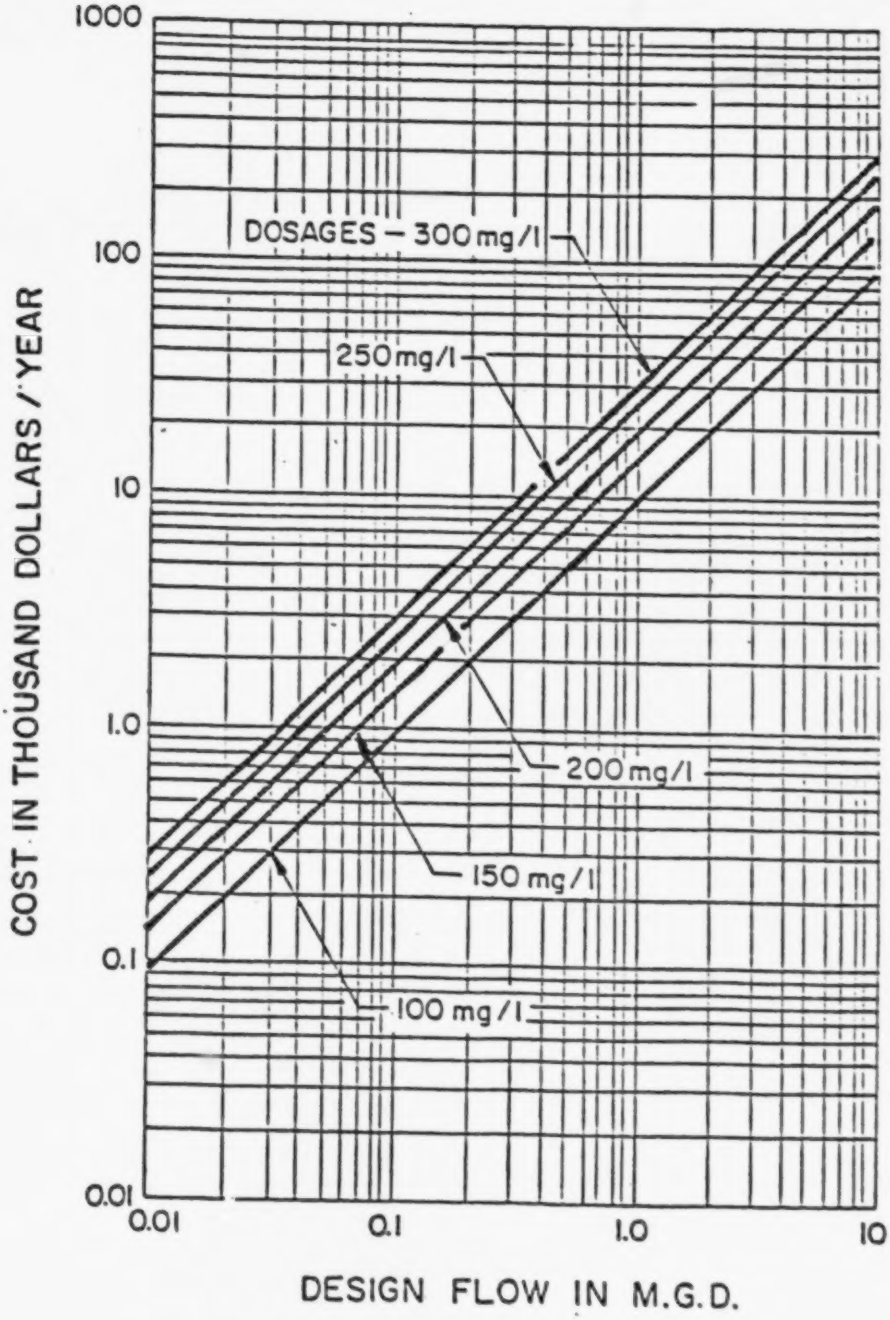


Figure VIII-34

POST MINING DISCHARGE LIME ADDITION ANNUAL COST CURVES FOR UNDERGROUND COAL MINE ACID WASTEWATER TREATMENT WITH SEDIMENT PONDS OR CLARIFIERS

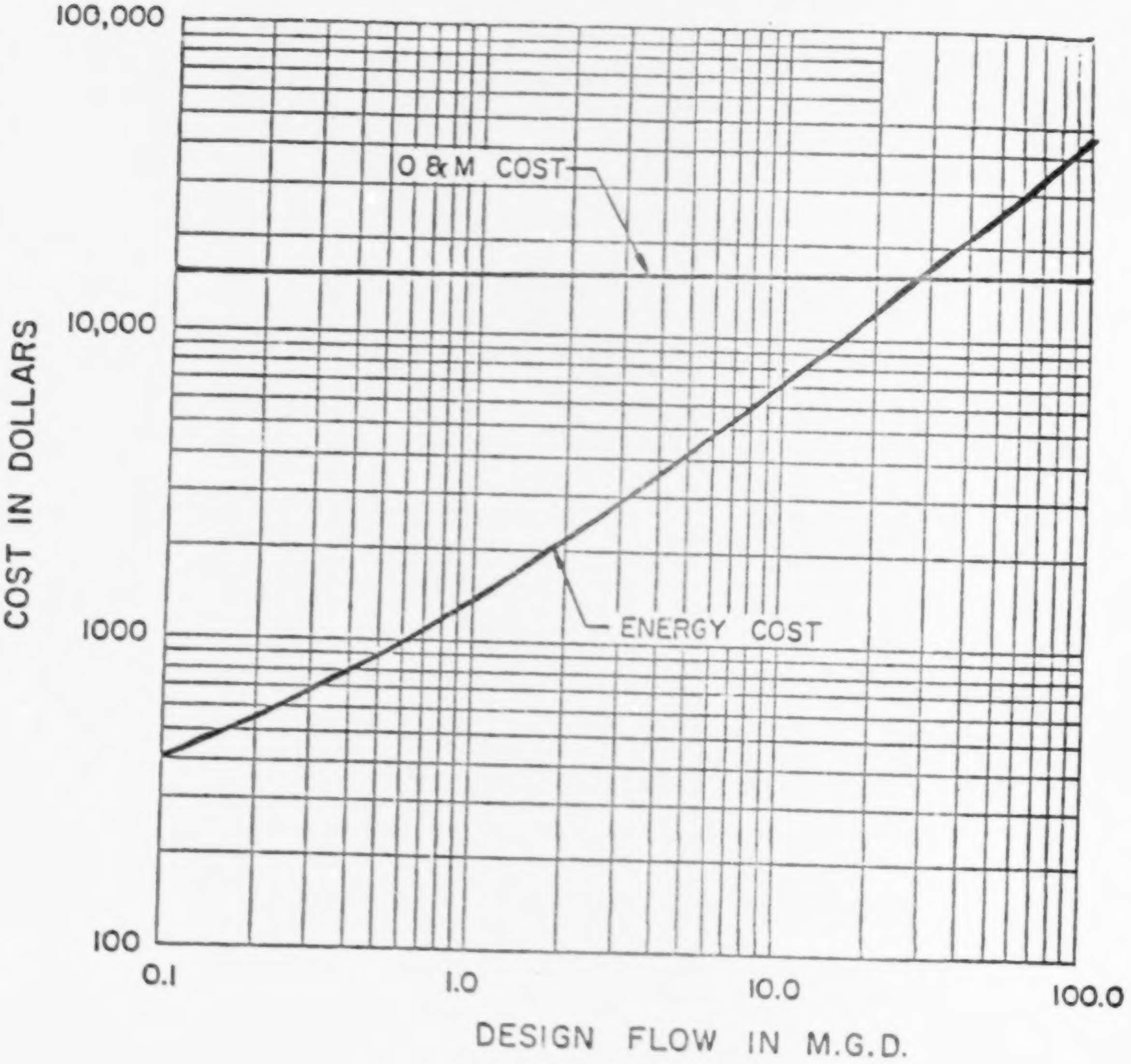


Figure VIII-35

POST MINING DISCHARGE LIME FEED FACILITIES OPERATION AND MAINTENANCE ANNUAL COST CURVES FOR UNDERGROUND COAL MINE ACID WASTEWATER TREATMENT WITH SEDIMENTATION PONDS OR CLARIFIERS

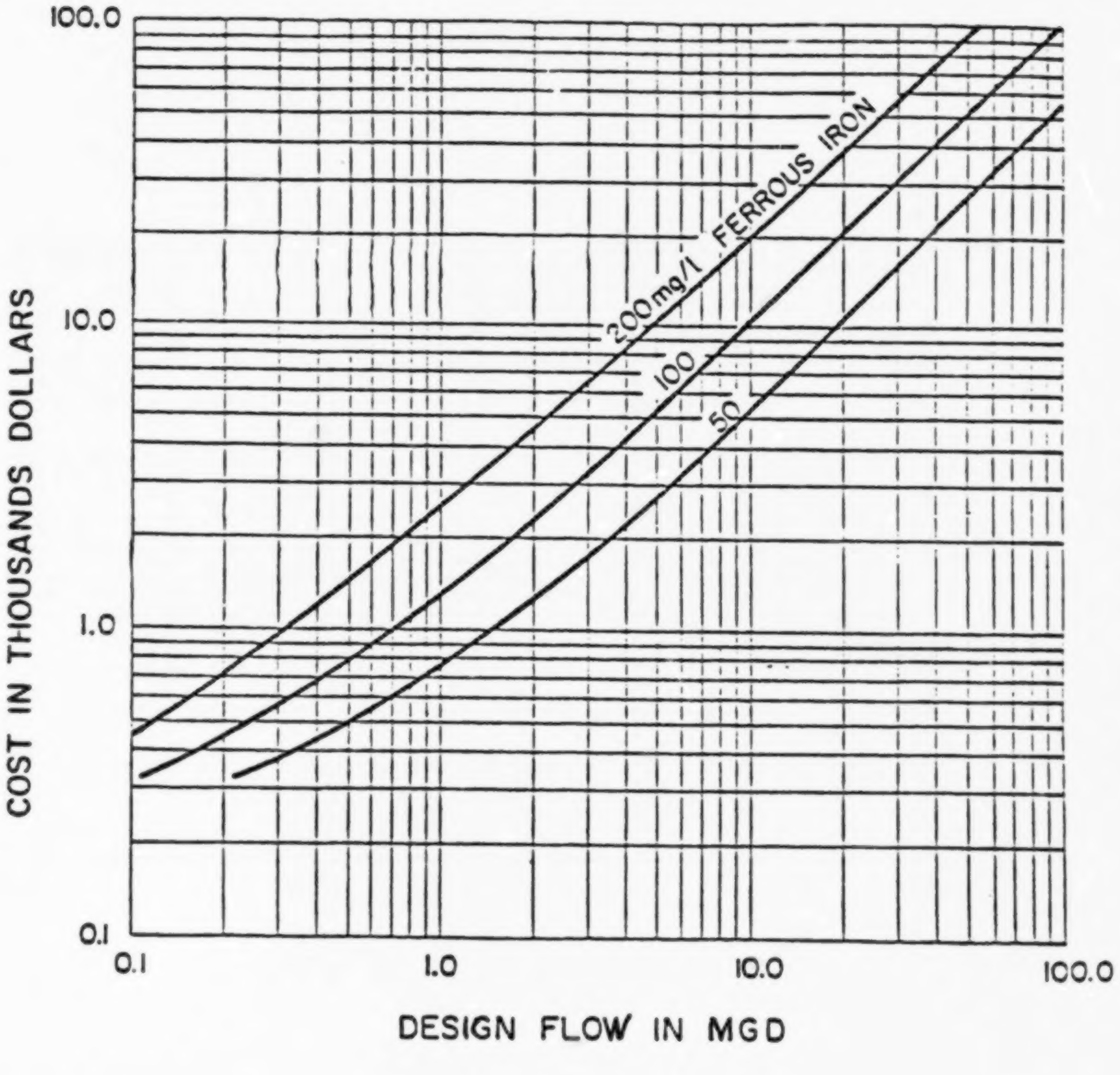


Figure VIII-36

POST MINING DISCHARGE AERATION OPERATION
AND MAINTENANCE ANNUAL COST CURVE FOR UNDERGROUND COAL
MINE ACID WASTEWATER TREATMENT WITH SEDIMENTATION PONDS
OR CLARIFIERS

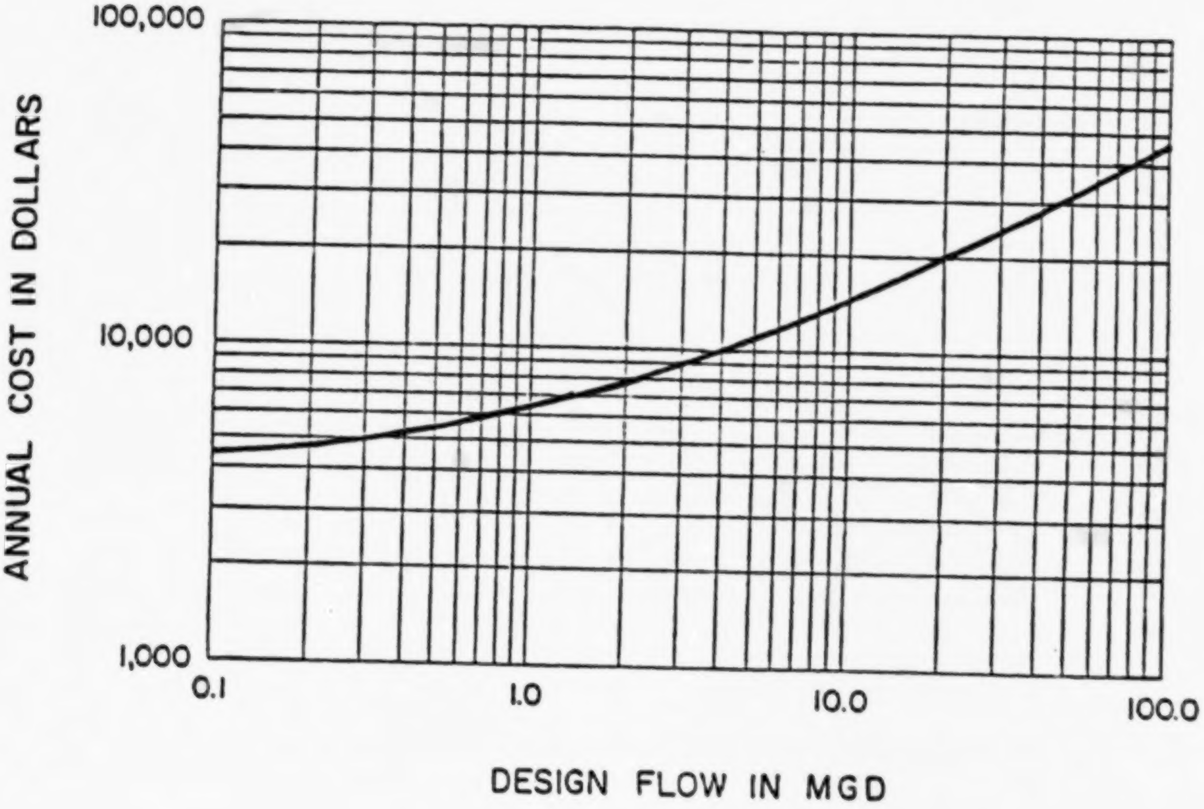


Figure VIII-37

AFTER MINE CLOSURE CLARIFIER MECHANISM AND SLUDGE PUMPING OPERATION AND MAINTENANCE ANNUAL COST CURVE FOR UNDERGROUND COAL MINE ACID WASTEWATER TREATMENT WITH CLARIFIERS addition, and aeration), add the costs from Figure VIII-37 to the costs obtained from Figures VIII-34, VIII-35, and VIII-36.

GENERAL ASSUMPTIONS UNDERLYING CAPITAL COSTS FOR ALL SUBCATEGORIES

Building Costs

Buildings will be required to house chemical and polymer feed equipment, as well as the controls for the treatment systems. The cost estimates were prepared by including various subcategories, i.e., costs for concrete, superstructure, plumbing, sanitation, and lighting. The electrical and control panel costs as well as laboratory facilities and office equipment are included in the building costs. These costs are included in the capital cost curves for each of the treatment levels.

Piping

The type of piping costed for each treatment system is carbon steel. Pipe diameters were sized based on six to seven feet per second flow velocity. The costs for piping were based on up-to-date pipe cost quotations and a factor of 100 percent was added to this cost to account for fittings, flanges, hangers, excavation, and backfilling as required.

Electrical and Instrumentation

The electrical and instrumentation costs for the treatment levels were estimated at 30 percent of the cost of the applicable equipment.

Power Supply for Mine Water Treatment

Operation of the equipment associated with the three candidate levels of BAT treatment may require additional electric power at the site. This power can be supplied by either running a power line from an accessible trunk line or power source, or by using diesel powered generator units. The worst case would probably be to run a high voltage trunk line from a generating facility long distances to the wastewater treatment facility. In addition to the capital cost for power line construction, associated costs for metering, transformers and secondary lines would be required.

In order to provide information on the costs for running power lines, two supply voltage levels were assumed: 480 volts and 4.16 kilovolts. It was then assumed that the practical breakpoint on transmission distance would be between 500 to 1,000 feet for 480 volts. Distances approaching 1,000 feet and longer would require a feeder of 4.16 kV.

Table VIII-3 has been prepared to present approximate cost for power lines. If the distance from the source and user and the load in kilowatts (kW) is known, the table can be used to obtain the power line costs. These prices include installation, poles, wire, insulators and crossarms for 480 volts and also includes a power center at the user containing a high voltage incoming section with necessary protection disconnecting devices, transformer (4.16 kV/480V) and secondary side circuit breaker.

In cases where trunk or secondary lines are not readily available, it may be advantageous to operate diesel engine generator units. The range of approximate power requirements for the three candidate levels of BAT is from 5 kw at the lowest flow rate, level 2, to 150 kw for the highest flow rate, level 4. An economic tradeoff exists between the relatively low capital cost for a diesel unit and the relatively low maintenance and operating costs of a long distance trunk line system. Table VIII-4 provides cost estimates for diesel generator units for a range of power requirements. The costs presented in Table VIII-4 include an ICC approved weather-housed trailer with controls, cables, battery muffler system, alternator, control panel, silencer, diesel engine, and generator. Capital costs for electric power supply do not include land requirements and are not included in the capital cost curves presented for the various treatment levels, due to the highly site-specific nature of these costs. No extensive power requirements are necessary at the preparation plants since power is already available for production equipment.

Land

Additional land may have to be purchased in order to comply with BAT/NSPS. This cost is difficult to estimate on a general basis since the information received during the mine visits indicated that the cost can vary from a few hundred dollars to $40,000 per acre. If additional land is required, land costs must be added to the capital cost obtained from the treatment level system curves. The amount of land needed for proposed BAT alternatives is presented on an individual equipment basis for each level of treatment suggested (1). A value of $4,000 per acre is assumed to be a reasonable cost because it is a representative cost of land in a rural location in the midwest.

Equipment

The equipment costs included in this subsection are for polymer addition equipment, pump stations, mixing tanks, clarifiers, gravity filters, and water storage tanks. This encompasses equipment required for all three treatment levels. Cost estimates for installation, engineering, administration, and contingencies are also included.

Polymer Addition Equipment. Capital costs of polymer addition equipment are relatively insensitive to mine drainage flow rates according to vendor price quotations. Below 750,000 gpd the installed capital cost was estimated at $30,000 and above 750,000 gpd the cost

Table VIII-3

COST OF OVERHEAD ELECTRICAL DISTRIBUTION SYSTEMS

480V System

Distance ft	LOAD - KW					Notes
	100	200	300	400	500	
250	$1500	$1900	$2100	$2500	$3100	
500	$3200	$4900	$5500	$6700	*	*Voltage drop excessive

4.16 KV System

Distance ft	LOAD - KW					Notes
	100	200	300	400	500	
1000	$19,000	$19,000	$20,000	$23,000	$23,000	Power center costs included
1500	$20,400	$20,400	$21,400	$25,000	$25,000	" "
2000	$22,000	$22,000	$23,000	$26,600	$25,600	" "
2500	$23,500	$23,500	$25,300	$29,600	$29,600	" "
3000	$25,000	$25,000	$26,000	$31,500	$31,500	" "
3500	$26,600	$27,700	$28,700	$36,300	$36,300	" "
4000	$28,000	$29,400	$32,400	$38,600	$38,600	" "
4500	$29,800	$31,200	$34,400	$41,000	$41,000	" "
5000	$31,300	$32,900	$36,400	$49,700	$49,700	" "

Reference (2)

Table VIII-4

CAPITAL COSTS FOR DIESEL GENERATOR SETS

Generator Type	Power Requirement (Kw)	Cost (1000$)
Air-Cooled	10	11
Air-Cooled	30	16
Radiator-Cooled	55	20
Radiator-Cooled	100	24
Radiator-Cooled	150	30

Reference (4)

estimate was $40,000. These costs include a mixing tank, feed pump, transfer pump, storage tank, an enclosure, and an electric heater. Costs for the enclosure and heater were additional to those given by the vendors of the polymer equipment. The costs for these two items were estimated at $10,000 for the enclosure and $6,000 for the heater.

Pump Stations. Installed capital costs for pump stations include a 3/8 inch steel structure, pumps and motors, piping, valves, fittings, structural steel (stairwells, ladders, ancillary equipment), electrical equipment and instrumentation. Two pumps were assumed for all flow rates up to 3.0 mgd; above this flow rate three pumps were used.

Mixing Tanks. The cost for the mixing tanks used in level 3 includes three steel tanks and skids, three mixers, nine slide gates, structural steel, aeration systems (blowers and piping), electrical equipment, and instrumentation.

Flocculator-Clarifiers. A flocculator-clarifier composed of a steel tank (1/4 inch thick) in concrete base, the internal flocculation and sludge scraping mechanisms, structural steel, slide gates, sludge pumps and motors, electrical equipment and instrumentation.

Gravity Granular Media Filters. The equipment included with gravity filters is composed of a concrete pad, a backwash water storage tank, piping connections, filter cells, media, underdrain system, electrical equipment and instrumentation. The filters were sized based on a flux rate of 10 gpm/ft^2.

Installation. Installation is defined here to include all services, activities, and materials required to implement the described wastewater treatment systems. Many factors affect the magnitude of this cost including wage rates, in-house or contracted construction work and site dependent conditions. The installation costs are included in capital cost estimates presented in this section.

Engineering, Administration and Contingencies. The costs associated with taxes, insurance, engineering, administration, and contingencies are computed as 25 percent of the installed cost of facilities and equipment.

GENERAL ASSUMPTIONS UNDERLYING ANNUAL COSTS FOR ALL SUBCATEGORIES

The annual costs computed for each of the treatment systems suggested for BAT are categorized as follows:

Amortization

Operation and Maintenance
    Labor
    Materials and Supplies
    Chemicals
Energy

Amortization

The annual depreciation and capital costs are computed based on using the capital recovery factor:

$AC = (II)(CRF)$

where

AC = annual cost

II = initial investment

CRF = capital recovery factor = $(r)^n(1+r)/((1+r)^n-1)$

r = annual interest rate

n = useful life in years.

An interest rate of 10 percent was used in all cases. The expected life differs for civil construction work and mechanical and electrical equipment items and their installation, i.e., the expected life for civil construction work is 30 years and 10 years for installed mechanical and electrical equipment. No residual or salvage value is assumed. Based on these assumptions, the general multipliers (AC/II) compute as follows:

$CRF\ (civil)_{30} = 0.10608$

$CRF\ (mech.\ \&\ elec.)_{10} = 0.16275$

Operation and Maintenance

General. Operating time of the systems costed is assumed to be for 24 hours per day, 365 days per year.

Operating and Maintenance Personnel. Personnel costs are based on an annual rate of $28,000.

Maintenance Materials. The materials necessary for performing yearly maintenance activities are estimated at three percent of the capital cost of the facilities including the contingency item.

Chemicals. The chemicals costed for use in any of the levels of treatment are polymer and lime. The polymer cost is estimated at $2.00 per pound, lime estimated at $65/ton. Yearly costs will vary according to the dosage level used in the treatment system. A polymer dosage rate of two mg/l was selected for computing annual polymer costs in each applicable system.

Power Costs. Electricity costs are based on auxiliary power requirements in terms of kilowatts and 8,760 hours per year of operation. The cost per kilowatt hour is estimated at $0.03 (2).

SLUDGE HANDLING AND ASSOCIATED COSTS

The sludge produced in the treatment of mine drainage, preparation plant effluent and pond sedimentation can be handled by various methods. Three methods which may be used and are considered in this report are: sludge lagoons, trucking of dewatered sludge to disposal site and trucking of undewatered sludge to disposal site.

Sludge Lagoons

The sludge lagoon would require construction of a lagoon and pumping the sludge from the treatment facility to the lagoon. Available data for lime neutralization indicates that sludge production is about 10 percent by volume of the incoming flow (solids concentration of two percent) (1). This sludge would compact in a lagoon to 10 percent solids which equates to three percent by volume of the incoming flow treated. To arrive at a cost it is assumed that the sludge storage requirements would be for an estimated 10 year life of the mine. The cost curves for capital and yearly cost for the sludge lagooning approach are shown in Figure VIII-38.

Haulage of Dewatered Sludge

The method of dewatering sludge considered here consists of pumping the sludge to a thickener. The thickened sludge is then dewatered by vacuum filters before hauling to disposal. It is assumed that this system will increase the solids loading in the sludge to about 25 percent. The cost curves for capital and yearly costs, as well as energy requirements for this dewatering, are shown in Figure VIII-39. The estimated cost for hauling dewatered sludge to disposal sites, based on a one round trip mile, is presented in Figure VIII-40. To maintain a uniform cost basis, this curve is a plot of design flow in mgd versus cost in thousands of dollars.

Haulage of Undewatered Sludge

The final sludge handling approach is to haul the sludge to disposal sites without dewatering. This involved pumping the sludge at about two percent solids to a tank truck and then hauling to a disposal site where it is lagooned or pumped into a bore hole. The trucking cost

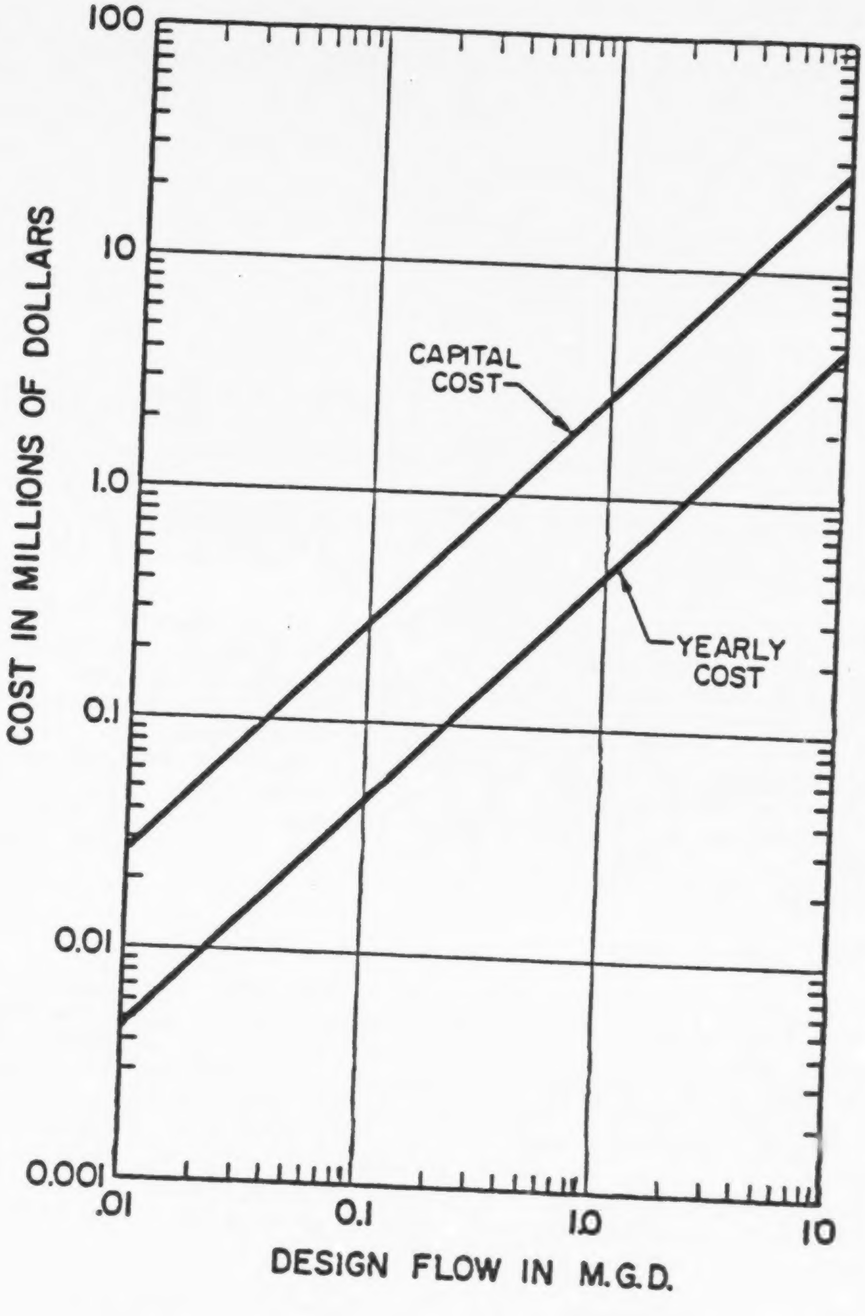


Figure VIII-38
MINE DRAINAGE TREATMENT
SLUDGE LAGOON VERSUS DESIGN FLOW

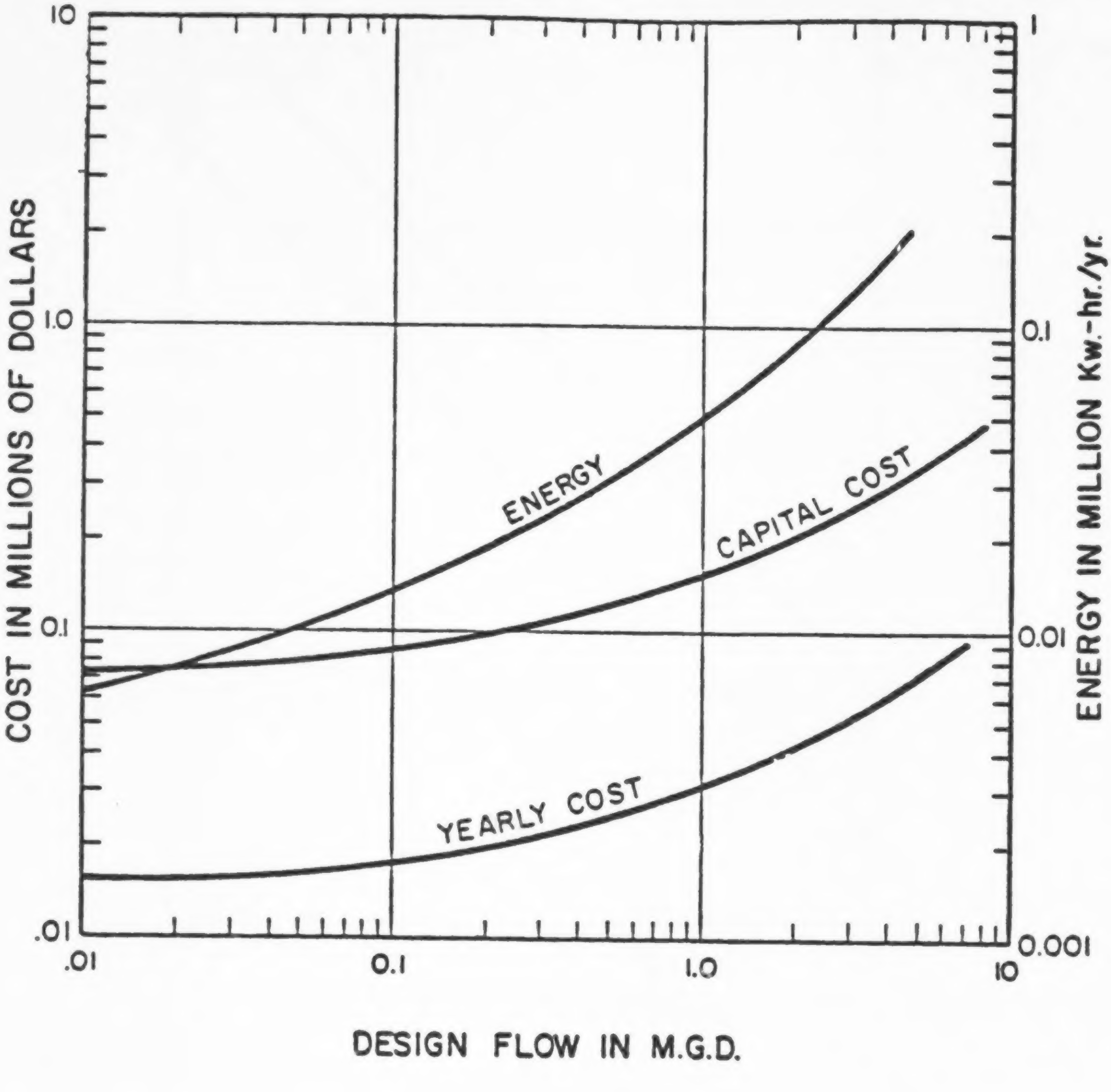


Figure VIII-39

MINE DRAINAGE TREATMENT
SLUDGE DEWATERING VERSUS DESIGN FLOW
COST AND ENERGY CURVES

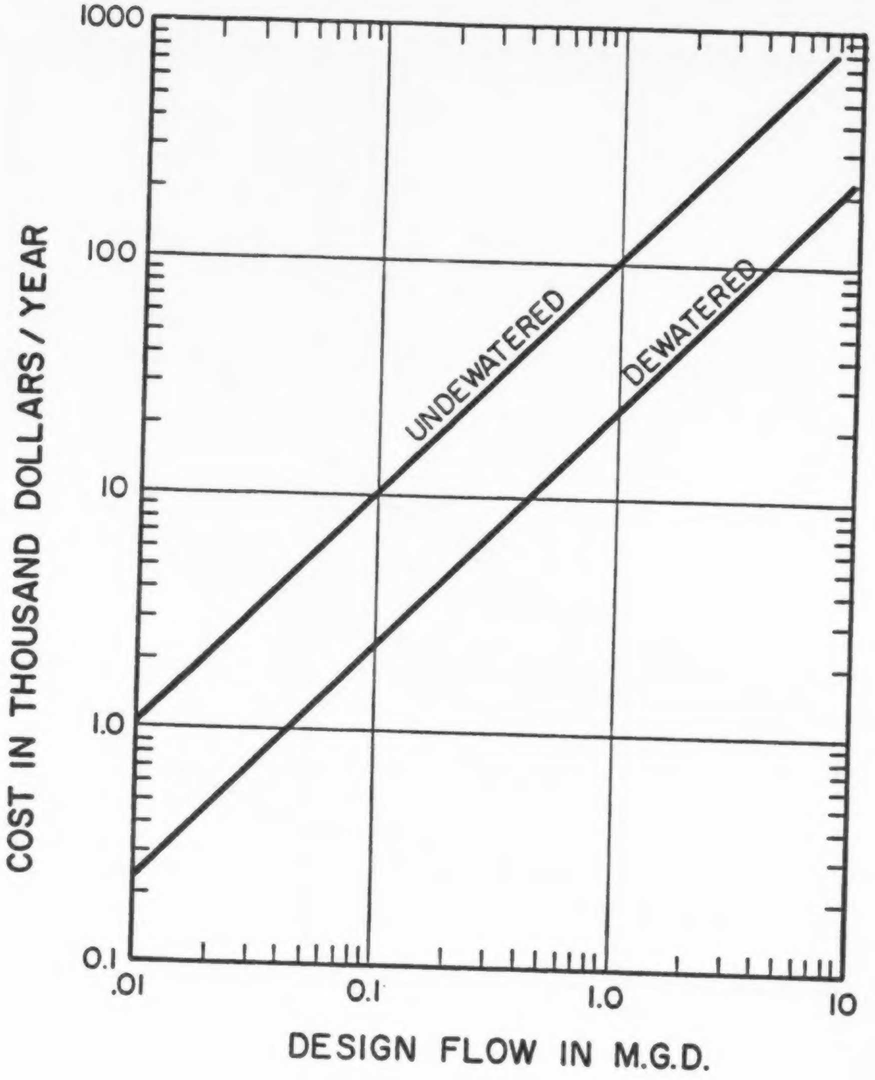


Figure VIII-40

YEARLY COST OF ONE ROUND TRIP MILE
OF SLUDGE HAULING VERSUS DESIGN FLOW
MINE DRAINAGE TREATMENT

for hauling this sludge, based on a round trip mile, is also presented in Figure VIII-40. Assumptions and cost criteria for sludge handling are based on information provided in reference (2). To calculate the cost of land, Figure VIII-41 presents the sludge lagoon area required versus mine drainage flow rates.

REGIONAL SPECIFICITY FOR COSTS

Variations in capital and annualized costs are dependent on the region in which the treatment facility is located. These differences are due to such factors as soil type, precipitation, topography, and vegetation. Cost multipliers have been prepared to reflect these cost differences and are presented in Table VIII-5 in the column entitled "Basic Capital Cost Multiplier." The development of these multipliers is presented in reference (5).

Before using these multipliers for a particular region, the extent to which certain costs have already been absorbed in establishing BPT facilities should be determined; this may require a certain degree of downward multiplier adjustment in the cost. Items which affect the accuracy of these basic multipliers are previously built-in access roads, clearing and grubbing, etc.

The development of the Capital Cost Multiplier Adjusted to Civil Works was based on the premise that the multiplier is only applicable to that portion of the capital cost which is associated with excavation, backfilling, and concrete placement. The assumed contribution which these items provided in the overall construction investment is 40 percent. Thus, the basic multipliers are adjusted to 40 percent of their original value (5). Table VIII-5 also presents the formula which demonstrates the application of the adjusted capital cost multiplier to yearly costs. Regional cost multipliers for yearly cost would apply only to that portion of the yearly cost associated with the civil works part of the facilities, such as the civil works portion of the amortization and associated charges.

Examples of regionally specific cost determination procedures are provided in the cost manual (1).

NON-WATER QUALITY ASPECTS

Table VIII-5

COST MULTIPLIERS FOR COAL MINING REGIONS IN THE UNITED STATES

Region	Basic Capital Cost Multiplier	Capital Cost Multiplier Adjusted to Civil Works
Northern Appalachia	1.8	1.32
Central Appalachia	1.8	1.32
South Appalachia	1.7	1.28
Midwest	1.3	1.12
Central West	1.2	1.08
Gulf	1.0	1.0
Northern Great Plains	1.0	1.0
Rockies	1.9	1.36
Southwest	1.65	1.26

NOTES:

To obtain the adjusted yearly cost for a region where the capital cost multiplier is greater than one use the following formula:

$$\text{Adjusted Yearly Cost} = \text{Yearly Cost from Curve} - \text{Capital Recovery Factor} \times \text{Yearly Cost from Curve} \times 1 - \text{Capital Cost Multiplier}$$

Reference (5)

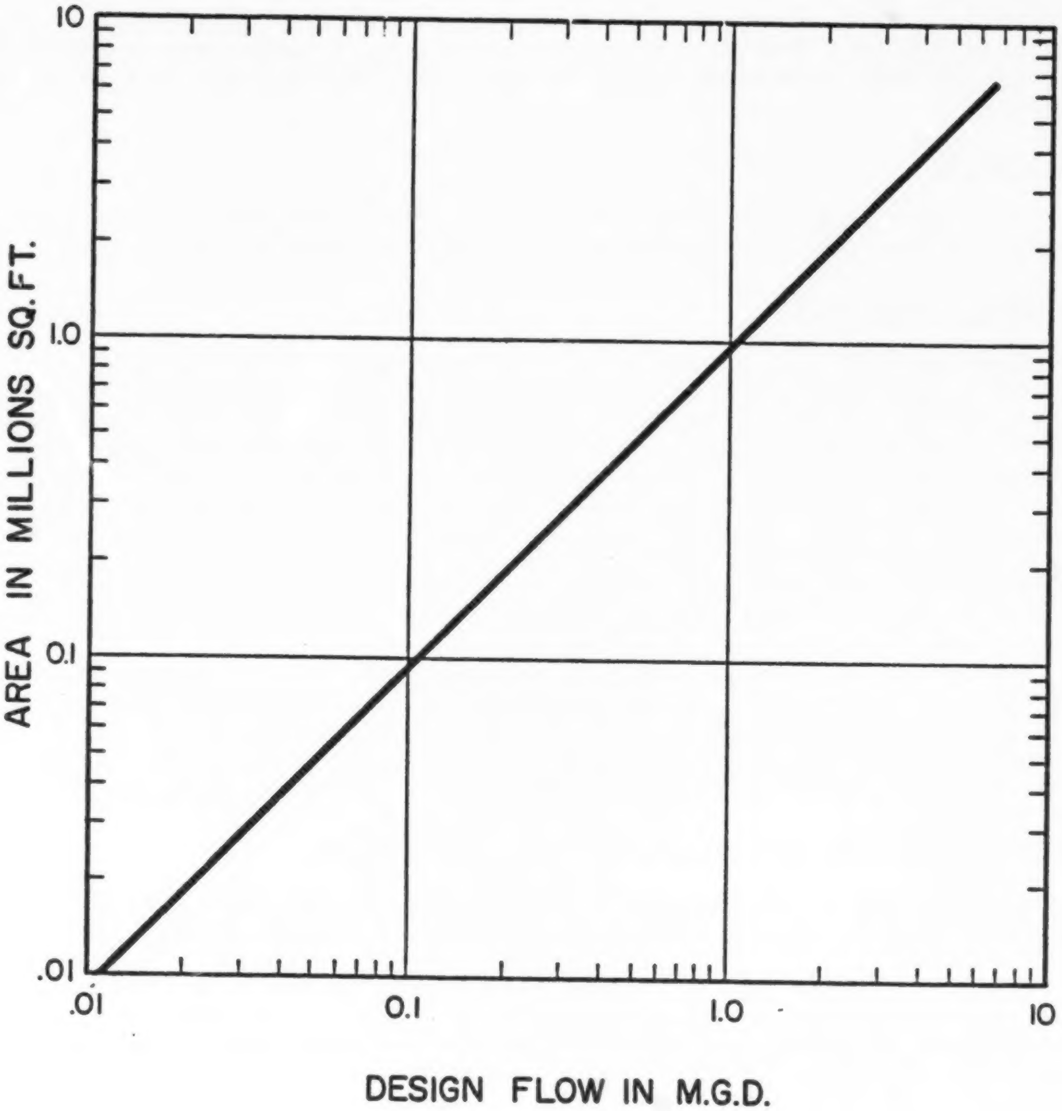


Figure VIII-41

SLUDGE LAGOON - AREA REQUIRED VERSUS DESIGN FLOW
MINE DRAINAGE TREATMENT

The effects of the candidate technologies on air pollution, solid waste generation, and energy requirements have been considered. The latter aspect has been addressed in earlier subsections, and will not be repeated.

Air Pollution

Imposition of regulations based on any of the candidate technologies in any subcategory will not create any additional air pollution.

Solid Waste Generation

The neutralization and aeration of acid mine drainage results in a suspension of ferric hydroxide, other metal hydroxides, and unreacted reagents (lime) in an aqueous solution of salts composed largely of sulfates. This suspended matter must be removed before the water is discharged. Also, alkaline drainage contains sediment which requires removal. Many preparation plants in the United States use water to assist in the sizing, separation, and cleaning of run-of-mine coal. The waste slurry discharged from the plant is often high in suspended coal fines that require reduction or removal prior to recycle or discharge. Also, coal preparation facilities generate a solid or semisolid refuse of material rejected from the cleaned coal. Ash, clays, and other materials make up this refuse, which is conveyed as a slurry to a refuse pile, or disposed of in some other manner. The creation of these sludges result from application of the BPT requirement. Additional sludge generation resulting from the candidate technologies are discussed in the following paragraphs.

Flocculant Addition and Granular Media Filtration

For mine drainage or preparation plant wastewaters, the application of these technologies would result in additional sludge production of a composition similar to sludge generated by BPT requirements. However, the amount of this extra solid waste would be minimal in comparison with quantities produced by compliance with BPT. For instance, in the acid drainage subcategory, the average TSS removal (which makes up a substantial portion of the solid waste) at a typical mine by application of BPT is 1,310 pounds per day. Installation of flocculant addition equipment would result in an additional estimated removal of 40 pounds per day, or a little over three percent of the BPT sludge production. For application of filtration technology, additional sludge production would be approximately 80 pounds per day, or less than 6.5 percent of the sludge produced under the BPT requirement.

Total Recycle Option-Preparation Plants

The total recycle option was considered only for preparation plant wastewaters (distinct from preparation plant associated area wastewater). As in the previous case, the additional sludge resulting from selection of the zero discharge option would be minimal. Again, using a typical facility, 370,000 pounds per day are removed from the wastewater by application of settling (BPT) technology (this figure does not include the small amounts of any gypsum or other "spectator" solids that might settle). Installation of facilities to achieve total recycle would remove an additional 140 pounds per day from waters discharged to the environment.

Settling - Reclamation Areas

The Agency is promulgating effluent limitations for areas under reclamation and for sites where mining has ceased. Because these limitations are based on a technology (a sedimentation pond) whose installation is already required by active mining regulations there will be no incremental non-water quality impacts resulting from the EPA rule for post-mining regulations. Because the composition of the settled material does not include toxic metals, the environmental impacts of solid waste disposal in this subcategory are projected to be minimal.

SECTION IX

AMENDMENTS TO BPT

The following are amendments to the previously promulgated BPT regulations (42 FR 21380 (April 26, 1977)). These changes also apply to BAT and NSPS presented in the following sections.

WESTERN MINES

As discussed in Section V, western mines will no longer be a separate subcategory.

POST MINING DISCHARGES

This subcategory was established (as "areas under reclamation") during the NSPS rulemaking, but the Agency deferred promulgation of any limitations until further data could be gathered and analyzed. As discussed in Sections V and VII, additional data have been collected that support the establishment of effluent limitations for this subcategory.

Reclamation Areas

Pollutants to be regulated for reclamation areas include settleable solids and pH. The technology basis on which these limitations are based is a sedimentation pond capable of containing the runoff from the reclaimed area resulting from a 10-year, 24-hour storm. The Agency has concluded that the following limitations shall apply to the reclamation areas for mining of coal of all ranks including, but not limited to, lignite, bituminous, and anthracite:

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Effluent Characteristic	Effluent Limitations Maximum for Any One Day	 30 Day Average
Settleable Solids	0.5 ml/l	----
pH	within the range 6.0 to 9.0 at all times	----

These regulations shall apply until full release of the SMCRA performance bond.

Underground Mine Discharges

Effluent limitations for underground mines shall be the same as those for active mines because the wastewater characteristics are not significantly different as discussed in Sections V and VII.

ALTERNATE LIMITATIONS DURING PRECIPITATION EVENTS

EPA is amending the exemption available for discharges caused by precipitation events. EPA's studies have shown that well-operated treatment facilities can achieve settleable solids and pH limitations during rainfall events of varying intensity as discussed in Section V and VIII. The "storm exemption" published on December 28, 1979 (44 FR 76788) is being modified as follows:

(1) Settleable solids and pH limitations will apply to discharges, overflows, or increases in discharges caused by precipitation events less than or equal to a 10-year, 24-hour storm event.

(2) Only pH limitations will apply to discharges, overflows, or increases in discharges caused by precipitation events greater than a 10-year, 24-hour storm event.

(3) The alternate limitations apply to coal mining operations regardless of the treatment installed; there is no requirement to install a "10-year, 24-hour pond", or indeed any pond at all. This requirement has been deleted in conformity with the July 2, 1981 proposal by OSM, to allow mining operations flexibility in designing their treatment systems. The limitations on settleable solids of 0.5 ml/l and pH (range of 6-9) are based on the treatment capability

of a pond designed, constructed and maintained to contain the volume of water which would drain into the pond from active mining areas and reclaimed areas during the 10-year, 24-hour precipitation event. (See Section VII).

(4) Discharges from underground mines are not eligible for the alternate limitations unless they are commingled with surface discharges. Precipitation does not significantly affect the mechanism of underground mining discharges, and thus relief from effluent limitations is not necessary. Techniques for preventing or minimizing infiltration in underground mines is presented later in this section.

Costs to comply with the storm exemption are less than those originally required in the BPT regulations because a 10-year, 24-hour pond is not required. Smaller ponds or other treatment options may be used and the facility may still qualify for the alternate limitations.

Any overflow, increase in volume of a discharge or discharge from a bypass system caused by precipitation within any 24-hour period less than or equal to the 10-year, 24-hour precipitation event (or snowmelt resulting in equivalent volume) shall be subject to the following alternate limitations:

	Effluent Limitations	
Effluent characteristic	Maximum for Any One Day	30 Day Average
Settleable Solids	0.5 ml/l	----
pH	within the range 6.0 to 9.0 at all times	----

Any overflow, increase in volume of a discharge or discharge from a by-pass system caused by precipitation within any 24-hour period greater than the 10-year, 24-hour precipitation event (or snowmelt resulting in equivalent volume) shall be subject to the following alternate limitations:

	Effluent Limitations	
Effluent Characteristic	Maximum for Any One Day	30 Day Average
pH	within the range 6.0 to 9.0 at all times	----

The Agency has decided to delete the design criteria to allow flexibility in treatment systems, consistent with OSM's proposed regulations.

SECTION X

BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE (BAT)

The factors considered in assessing best available technology economically achievable (BAT) include the age of equipment and facilities involved, the process employed, process changes, nonwater quality environmental impacts (including energy requirements) and the costs of application of such technology (Section 304(b)(2)(B)). In general, the BAT technology level represents, at a minimum, the best economically achievable performance of plants of various ages, sizes, processes, or other shared characteristics. Where existing performance is uniformly inadequate BAT may be transferred from a different subcategory or category. BAT may include process changes or internal controls, even when not common industry practice.

Under the Clean Water Act amendments of 1977, the primary emphasis of BAT is the control of toxic pollutants. The statutory assessment of BAT "considers" costs, but does not require a balancing of costs against effluent reduction benefits. In developing the final BAT, however, EPA has given substantial weight to the reasonableness of costs. The Agency has considered the volume and nature of discharges, the volume and nature of discharges expected after application of BAT, the general environmental effects of the pollutants, and the costs and economic impacts of the required pollution control levels. Despite this expanded consideration of costs, the primary determinant of BAT remains effluent reduction capability.

Effluent limitations in this industry are expressed as concentrations (i.e., mass per unit volume, most often milligrams per liter-- mg/l). Mass limitations cannot be written because wastewater flow cannot be correlated with coal production. This stems from the fact that, although little process water is employed in coal extraction, large volumes of water still require treatment because of infiltration from precipitation and runoff through the active mining area as well as groundwater seepage from breached aquifers. Thus a particular mine may have large volumes of water to treat that are essentially independent of the coal production capacity of the mine. This situation is also found in the coal preparation segment. Although process water used for coal cleaning can be correlated with production, wastewater flows are impossible to predict due to varying amounts of surface runoff from preparation plant associated areas such as coal stockpiles.

The Agency considered a number of options for regulation of existing sources subject to the BAT requirement and new sources subject to the

NSPS requirement. The BAT limitations options are detailed below. New source options are discussed in Section XII.

BAT OPTIONS CONSIDERED

General Applicability

Under all options considered and described below (except zero discharge for coal preparation plants) alternate limitations would be allowed for discharges caused by precipitation. The post-mining regulations apply to all options also (both the post-mining regulations and alternate storm limitations are the same as those presented in Section IX "Amendment to BPT").

Option One - BAT = BPT

For acid drainage mines and coal preparation plants and associated areas the limitations are based on the application of neutralization, aeration, and settling technology. For alkaline mines limitations are based on application of settling technology.

Option Two - BAT = BPT + Flocculant Addition Technology

A treatability study commissioned by the Agency has shown that when toxic metals were spiked into the untreated wastewater, substantial reduction of these pollutants was also achieved along with suspended solids. Additional toxic metal removals for BPT-treated water without spiking were highly variable due to the low influent levels of these metals. Costs for installation and operation of this technology would range from $30,000 to $40,000 per outfall for capital costs and from $.042/1,000 gallons treated to $.41/1,000 gallons treated for annual costs.* The cost of implementating this option at preparation plants and associated areas for the entire U.S. is 50.0 million dollars (capital) and 25.1 million dollars (annual) for this subcategory.

*Note: The lower cost was calculated assuming a two mg/l dosage rate and a 4.5 mgd facility; the higher cost was calculated assuming a two mg/l dosage rate and a 0.1 mgd facility.

Option Three - BAT = BPT + Granular Media Filtration Technology

Two acid drainage treatment plants were studied for evaluation of this technology. They consisted of BPT treatment (neutralization, aeration, and settling) of acid mine drainage followed by a dual-media filter. Toxic metal reductions are not quantified because influent concentrations of toxic metals to the filter were very low, i.e., the neutralization and settling processes effectively removed the priority metals contained in the raw wastewater. Capital costs for this technology range from $150,000 for a design flow of 100,000 gpd to $900,000 for a design flow of 8,000,000 gpd. Annual costs for filtration range from $.51/1,000 gallons treated for the 100,000 gpd facility to $.055/1,000 gallons treated for the 8 mgd facility. No capital and annual costs were estimated for implementation of this option specifically for preparation plants and associated areas.

Option Four - BAT = Zero Discharge for Coal Preparation Plants

Associated area drainage would be segregated from preparation plant wastewaters for separate treatment. Total recycle of preparation plant water would be necessary, with ditching or diking installed around the slurry pond to divert storm and other surface runoff. Makeup water would be provided from an independent source. An occasional purge, subject to BPT, would be allowed when necessary to reduce the concentration of solids or process chemicals in the water circuit to a level which will not interfere with the preparation process or process equipment. Associated area drainage would, if required, be neutralized and settled in a separately constructed facility. Option 1 thru 3 would be considered for the mine drainage subcategories. The alternate limitations for precipitation events will not apply to new source preparation plants. Total industry capital costs for implementation of this option are estimated to total 291.2 million dollars. Annual costs are estimated at 52.6 million dollars.

BAT SELECTION AND DECISION CRITERIA

EPA has selected Option One (BAT = BPT) as the basis for final BAT effluent limitations. Additional removal of toxic compounds by Options Two and Three is insignificant. There was some additional removal of iron and manganese, however the costs associated with installation and operation of these technologies are too high to warrant such removal. These options provided only small incremental toxic metal removals and in some cases exhibited virtually no additional removal at all. Thus, lower BAT limitations based on these technologies could not be justified. Suspended solids removals were quantifiable; however, TSS is subject to BCT, not BAT limitations. These technologies will be subject to the BCT "cost reasonableness" test when it is promulgated; until then, BCT limitations are reserved for the coal mining industry. Option four for existing preparation plants was not selected based upon the high retrofit expenditures. In the Agency's judgment, the costs of retrofitting for zero discharge are not justified by the effluent reductions that would result from that option. As noted in Section XII, "New Source Performance Standards (NSPS)," the zero discharge option was selected for new source preparation plants because no retrofit costs were involved. The BAT effluent limitations guidelines for the coal mining category are summarized in Table X-1.

BEST MANAGEMENT PRACTICES (WATER MANAGEMENT)

Section 304(e) of the Clean Water Act (33 U.S.C. 1251) authorizes the Administrator of EPA to promulgate Best Management Practices (BMPs) for each class or subcategory of both point and nonpoint sources of pollution. Under the Surface Mining Control and Reclamation Act of 1977 (SMCRA) (Public Law 95-87), OSM was assigned responsibility for the development of a comprehensive program to ensure environmental protection and land reclamation of surface coal mining operations. Water handling practices can include the application of various mining, aquifer and erosion control techniques to prevent or minimize adverse environmental effects. The purpose of these techniques is to effect a reduction in effluent water volumes and/or an improvement in effluent quality, thereby reducing wastewater treatment and its associated costs. The following paragraphs discuss water management practices available to operators and permit authorities to reduce wastewater quantity. For both surface mining and the surface effects of underground mining, OSM has promulgated specific regulations governing water management associated with mining and reclamation operations (44 FR 15143-15178). A number of these standards have been remanded as a result of litigation; therefore, OSM is now in the process of a new rulemaking.

Underground Mines

Surface or groundwater may enter underground mines from above, below, or laterally through adjacent rock strata. Faults, joints, and roof fractures are common sites of water entrance into abandoned underground mines. Water may also enter mines through exploration drill holes or through boreholes that supply power and air to underground equipment. Surface water can drain into underground mines from surface mines or as a result of inadequate stream diversion practices. Flooding or seepage from adjacent abandoned or inactive underground mines is often a significant source of water infiltration. Factors that can affect the quantity of water entering a deep mine are: the depth of the mine, the source of the drainage, the location of water bearing strata, and groundwater flow patterns. Investigations of the quantity of water entering underground coal mines have found the average rate of infiltration to vary between 6,260 and 10,280 liters per hectare per day (670 to 1,100 gal/acre/day). These rates may be exceeded if catastrophic flooding of a mine occurs from adjacent or overlying abandoned drifts (1). Various infiltration control practices are required in order to comply

Table X-1

EFFLUENT LIMITATIONS BASED ON BEST AVAILABLE TECHNOLOGY ECONOMICALLY ACHIEVABLE (BAT)

	Effluent Limitations (mg/l)	
Subcategory and Effluent Characteristics	Maximum for any one day	Average of daily values for 30 consecutive days shall not exceed
Acid Mine Drainage:		
Fe (total)	7.0	3.5
Mn (total)	4.0	2.0
Alkaline Mine Drainage:		
Fe (total)	7.0	3.5
Preparation Plants and Associated Areas:		
Fe (total)	7.0	3.5
Mn (total)	4.0	2.0
Post Mining Discharges:		
Areas Under Reclamation		
Settleable Solids	0.5 ml/l	---
pH	within the range 6.0 to 9.0 at all times	---
Underground Mine Discharges	Effluent limitations that apply from appropriate active mine drainage subcategory	

with OSM regulations restricting the discharge of water into underground mines (44 FR 15269 sec. 817.55). OSM requirements endorsed by EPA include:

1. Borehole sealing and casing
2. Mine sealing
3. Regrading and revegetation of surface facilities, and
4. Surface water diversion

Borehole Sealing

Underground mines are commonly intercepted by boreholes extending from the ground surface. These holes are sometimes drilled during mineral exploration, but may also be utilized for supplying power or air to underground equipment or for discharge water pumped from active sections. Upon abandonment of an underground mine, these boreholes may collect and transport surface and groundwater into the mine. These vertical, or nearly vertical, boreholes can be successfully sealed from below in an active underground mine. The sealing can also be achieved by placing packers and injecting a cement grout. Often abandoned holes will be blocked with debris and will require cleaning prior to sealing. The packers should be placed below aquifers overlying the mine to prevent entry of sub-surface waters, but should be well above the roof to prevent damage to the seal from roof collapse. A borehole may also be sealed by filling the hole with rock until the mine void directly below the hole is filled to the roof. Successive layers of increasingly smaller stone should be placed above the rock. A clay and/or concrete plug is then placed in the borehole. The remainder of the borehole may be filled with rock or capped.

Mine Sealing

Several techniques contained in the OSM program prevent postmining formation of acid mine drainage. One of these techniques is mine sealing. Mine sealing is defined as the closure of mine entries, drifts, slopes, shafts, subsidence holes, fractures, and other openings in underground mines with clay, earth, rock, timber, concrete, fly ash, grout, and other materials. The purpose of mine sealing is to control or abate the discharge of mine drainage from active and abandoned mines. Mine seals have been classified into three types based on method of construction and function. The three seal types are:

1. Dry Seal--The dry seal is constructed by placing suitable material in mine openings to prevent the entrance of air and water into the mine. This seal can be applied to openings where there is little or no water flow from within the mine and little danger of a hydrostatic head developing.

2. Air Seal--An air seal prevents the entrance of air into a mine while allowing the normal mine discharge to flow through the seal. This seal is constructed with a water trap similar to the traps in sinks and drains.

3. Hydraulic Seal--Construction of a hydraulic seal involves placing a plug in a mine opening that is discharging water. The plug prevents discharge after the mine is flooded. Flooding excludes air from the mine and retards the oxidation of sulfide minerals. However, the possibility of the failure of mine seals or outcrop barriers increases with time as the sealed mine workings gradually become inundated by groundwater and the hydraulic head increases. Depending upon the rate of groundwater influx and size of the mine area, complete inundation of a sealed mine may take several decades. Consequently, the maximum anticipated hydraulic head on the mine seals may not occur for a long time. In addition, seepage through, or failure of, the coal outcrop barrier or mine seal could occur at any time.

Surface Area Regrading

Water discharging from underground mines often originates as surface water from ungraded, unvegetated strip mine spoils. This commonly occurs in the eastern United States where coal outcrops are often mined by contour stripping techniques. These strip mines can intercept underground workings or have underground mine entries and auger holes located along the highwall. When these openings occur on the updip side of an underground mine, large volumes of surface water may be conveyed to underground workings. Surface mines may collect water and allow it to enter a permeable coal seam. This water can flow along the seam to adjacent underground mines.

The purpose of regrading is to return the disturbed area back to its approximate original contour, with natural drainageways and watersheds. Various methods of surface regrading have been practiced in the eastern coal fields. The selection of a regrading method will depend upon such factors as: the amount of backfill material available, the degree of pollution control desired, future land use, funds available and topography of the area. Prior to backfilling, impervious materials may be compacted against the highwall and coal seam to prevent the flow of water to adjacent underground mines. Where contour terrace regrading methods are applied, surface runoff is diverted away from the highwall.

Surface Water Diversion

Surface cracks, subsidence areas, ungraded surface mines, and shaft, drift and slope openings often are the source of surface water infiltration into underground mines. Water diversion entails the interception and conveyance of water around these underground mine openings. This procedure controls water infiltration and decreases the volume of mine water discharge.

Ditches, trench drains, flumes, pipes, and dikes are commonly used for surface water diversion. Ditches are often used to divert water around surface mines. Flumes and pipes can be used to carry water across surface cracks and subsidence areas. To ensure effective diversion, the conveyance system must be capable of handling maximum expected flows. Riprap may be required to reduce water velocities in ditch type conveyance systems.

In addition to the above practices required by OSM, permit writers may make use of the following water management practices to assure the control of infiltration into underground mines:

1. Surface or subsurface sealing
2. Channel reconstruction
3. Aquifer interception
4. Subsidence sealing and grading

Surface Sealing

Surface mines that overlie deep mines can collect water in a pit and this water could percolate into the underground facility. To control this, the surface permeability should be reduced. That can be accomplished by placement of impervious materials, such as concrete, asphalt, rubber, plastic, latex, or clay on the ground surface. Surface permeability may also be decreased by compaction; however, the degree of success will depend upon soil properties and the compaction equipment utilized.

A seal below the surface would have several advantages over surface seals: it would be less affected by mechanical and chemical actions; land use would not be restricted; and the seal would most likely be located in an area of lower natural permeability. The seal would be formed by injecting an impermeable material into the substrata. Asphalt, cement and gel materials have been used to control water movement below the surface. The effectiveness of various latexes, water soluble polymers, and water soluble inorganics, which hydrate with existing ground materials to form cement like substances, has been demonstrated in laboratory and field tests. However, large scale applications of subsurface sealants to control acid mine drainage have not been demonstrated.

Channel Reconstruction

Vertical fracturing and subsidence of strata overlying underground mines often create openings on the ground surface. Streams flowing across these openings may have a complete or partial loss of flow to the underground workings. During active operations, pumping of this infiltrating water is required. In both active and abandoned underground mines the problem of infiltrating stream flow can be effectively controlled by reconstructing and/or lining the stream channel. The reconstructed channel bottom may be lined with an impervious material to prevent seepage or flow to the underground mine. To ensure complete and effective diversion, the reconstructed channel must be capable of handling peak stream flows. In instances when stream flow cannot be diverted to a new channel, flow into underground mines can be controlled by plugging the mine openings with clay or other impervious material.

Aquifer Interception

This mine water handling technique utilizes hydrogeologic features of an underground mine in order to help prevent the inflow and contamination of groundwater. Wells are drilled from the land surface through the aquifer to the underground mine. The groundwater may then be drained through the mine zone for discharge into underlying aquifers, or conveyed from the mine through a pipe system.

Subsidence Sealing and Grading

Before or after abandonment of underground mines, fracturing or general subsidence of overlying strata can occur. This fracturing increases the permeability of the strata, and can result in the flow of large volumes of water into a mine. The volume of water that is diverted into an underground mine via fracturing or subsidence depends upon the structure of the overlying rock, and the surface topography and hydrology of the area. Vertical permeability may be decreased by placing impermeable materials around the subsided area. These materials may be compacted on the surface and graded, or placed in a suitable sealing strata below ground level. Materials which have been successfully utilized for subsidence sealing are rubber, clay, concrete, and cement.

Prevention of Acid Formation

Because sufficient water is almost always present in deep mines to allow acid formation, methods for reducing oxygen availability and contact time are important in preventing this reaction. Reduction of contact time can be accomplished during active operations by pumping water from the mine and maintaining the mine pool at a sufficiently low level. Pumping costs can be quite high, particularly if the water sources are diffuse; therefore, it is also good practice to try and reduce the amount of water flowing into the mine. For inactive or abandoned mines, mine sealing is a viable alternative. This method can eliminate oxygen from entering an underground mine.

Surface Mining

Water handling techniques for surface mines include practices associated with two categories: (1) mining technology, and (2) reclamation technology. Pre-mine planning to institute these practices is very important, as is borne out by the permit procedures required by OSM. The mining and reclamation techniques discussed in this subsection represent source control methods that can contain or prevent pollution formation during active mining.

Mining Methods

Certain mining techniques can help reduce the environmental impacts of coal strip mining. One such technique currently employed by industry and favored by OSM is termed "Modified Block Cut" mining. This method is basically applicable to moderate slopes (20% or less), low highwalls (60 feet average) and thin seams. It has been applied to mines located in the east This technique is expected to be feasible in even steeper terrain. The modified block cut method is a variation of conventional contour strip mining (2). Material from the first cut is often stored in a valley or head of hollow fill. This initial cut is usually three times wider than each succeeding cut in order to accommodate excess spoil as the mining plan progresses. After completion of each cut, a void is created near the highwall to store pollutant-forming materials encountered during mining. Overburden from the next cut is backfilled into the previous cut simultaneously exposing coal and initiating reclamation. This method offers several advantages:

1. Overburden is handled only once.
2. Most of the spoil is confined to a mined area,
3. Spoil on the downslope is almost completely eliminated thereby reducing the amount of disturbed area,
4. Reclamation is concurrent, and
5. Grading and revegetation areas are reduced.

Figure X-1 illustrates the "Modified Block Cut" method.

Excess Spoil Disposal

According to OSM regulations, spoil not used in returning the land to approximate original contour must be hauled and placed in a designated disposal area. The operator must ensure that leachate and surface runoff from the fill will not harm the surface waters or groundwater and the fill area must be suitable for reclamation. The regulations allow three types of fill design: valley, head-of-hollow, and durable rock.

A valley fill can be described as follows: a structure located in a hollow where the fill material has been hauled and compacted into place with diversion of upstream drainage around the fill. In addition, according to OSM regulations, valley fills must meet rules for subdrainage and filter systems.

Head-of-hollow fills are constructed in a manner similar to valley fills. However, instead of diverting upstream drainage around the fill, a rock-core chimney, constructed from the toe to the head of the fill, passes drainage through a fill core. In addition, head-of-hollow fills must completely fill the disposal site to the approximate elevations of the ridge line (3). Figure X-2 illustrates a head-of-hollow fill.

Durable rock fills represent a third type of valley fill but can be utilized only if the amount of durable rock (i.e., rocks which do not slake in water) is 80 percent of the total fill volume. Spoil material is dumped over a berm located at the head of the fill. The rock material forms a natural blanket drainway across the bottom of the fill. A drainage system is required but the regulations leave design open to the operator (3).

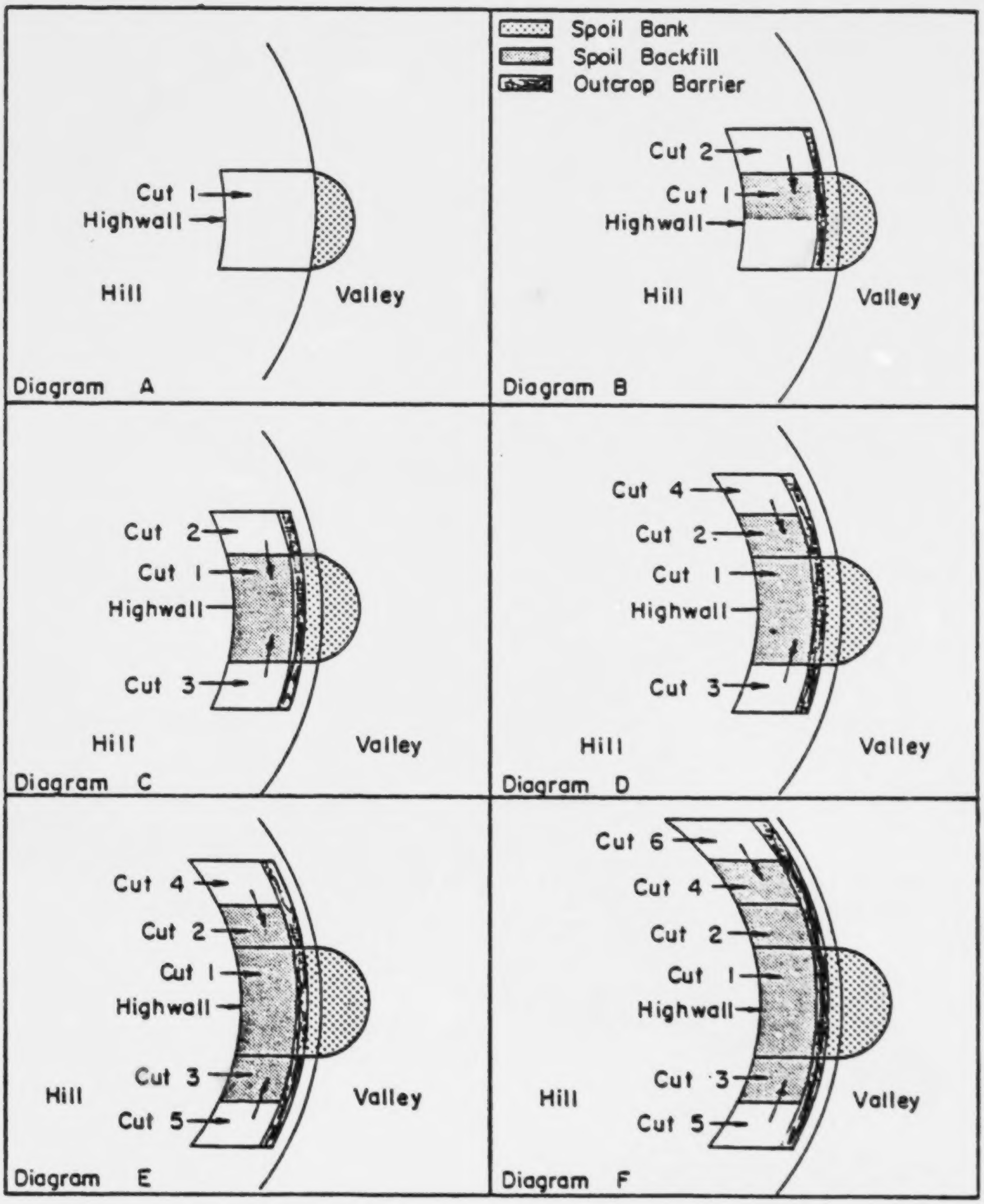


Figure X-1

MODIFIED BLOCK CUT

Source: (1)

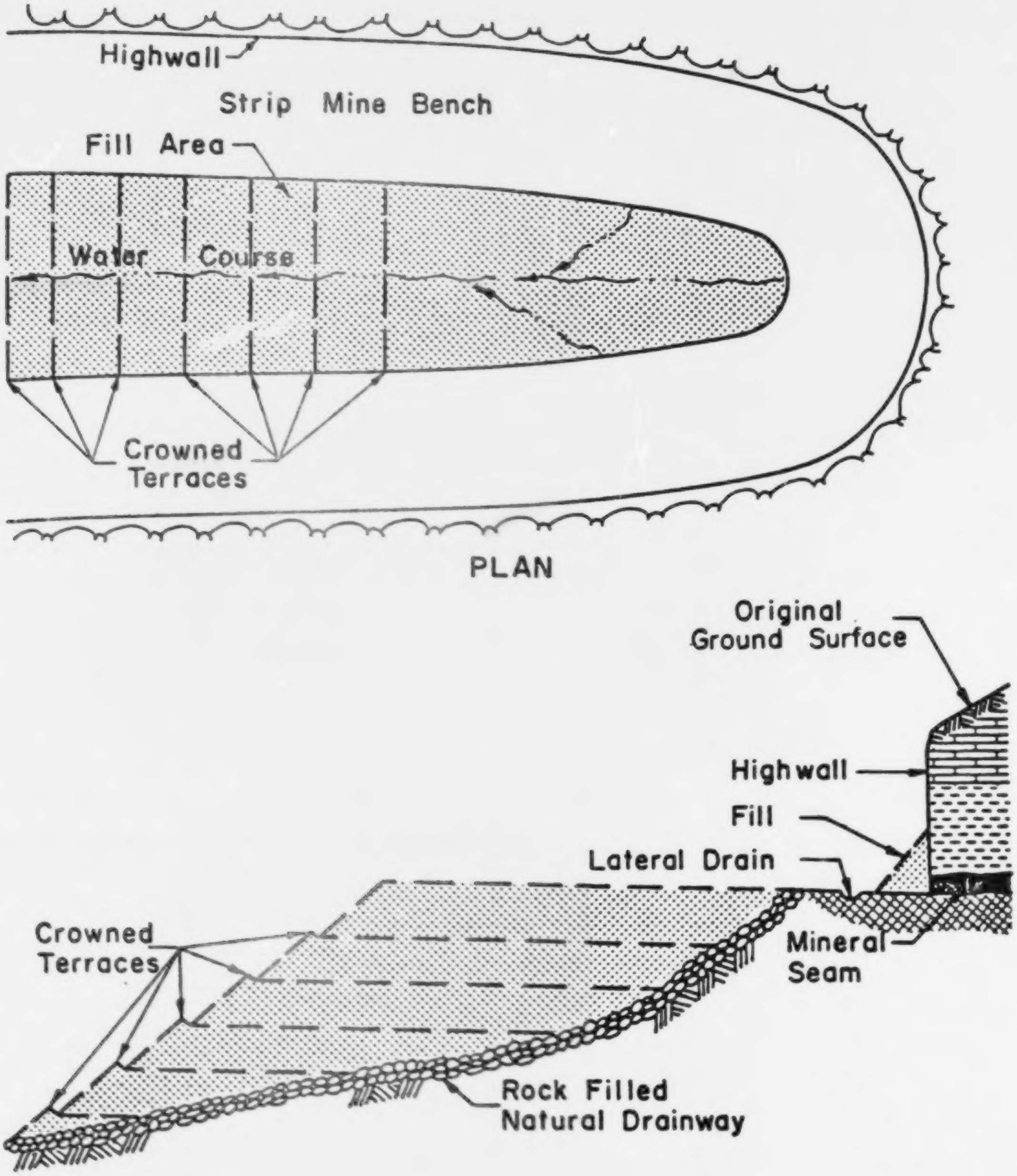


Figure X-2

CROSS SECTION OF TYPICAL HEAD-OF-HOLLOW FILL

Source: (1)

Reclamation

Proper reclamation techniques play a vital role in overall environmental quality control for any mining operation. Reclamation is considered an integral part of the overall mining plan. According to SMCRA, as contemporaneously as practicable with operations, all disturbed land shall be reclaimed to a condition equal to or exceeding any previous use which such lands were capable of supporting immediately prior to any exploration or mining function. Reclamation techniques center basically on regrading and revegetation.

Regrading

The purposes of regrading include the following:

(a) Aesthetic improvement of the land surface
(b) Returning the land to usefulness
(c) Providing a suitable base for revegetation
(d) Burial of pollution-forming materials
(e) Reducing erosion
(f) Eliminating landsliding
(g) Encouraging natural drainage
(h) Eliminating ponding
(i) Eliminating hazards, such as high cliffs, deep pits and deep ponds
(j) Controlling water pollution.

Regrading, as applied to surface mining, is currently defined as that of reconstructing the approximate original contour. Regrading is often more difficult in older surface mines where mining was conducted with less regard to environmental concern. For example, spoil was often placed without consideration of future regrading requirements. Contour strip mines in steep terrain create special problems where the spoil was deposited over the outslope. The terrain becomes difficult to cover with topsoil prior to regrading. Achieving a suitable surface for revegetation on abandoned mines becomes complicated because spoil segregation was rarely practiced. Topsoil usually was not segregated or stockpiled and pollution-producing materials are often well mixed throughout the spoil. This emphasizes the importance of regrading methods such as soil spreading and burying of pollution-forming materials. Revegetation techniques such as soil supplementation and spoil segregation are also important. Practices such as water diversion and sealing both underground mine openings and auger holes in highwalls can eliminate many erosional and/or pollution problems otherwise encountered during regrading and revegetation.

A major characteristic of most open pit mines or quarries is the large area required for disposal of overburden and processing wastes. Usually the required disposal acreage exceeds the actual pit area. Careful management of topsoil and overburden must be maintained for later use in land reclamation. Proper disposal of wastes avoids leaching of toxic materials from waste sites. Revegetation and regrading techniques help avoid water infiltration and severe erosion losses which could eventually result in landslides and severe pollutant loadings in nearby waters. Each of these practices is specified under OSM regulations.

Revegetation

Proper revegetation is one of the most effective pollution and erosional control methods for surface mined lands. Revegetation results in aesthetic improvement, and returns land to agricultural, recreational, or silvicultural usefulness.

A dense ground cover stabilizes the surface with its root system, reduces velocity of surface runoff, and functions as a filter to remove sediment from water flowing over and through it. This vegetative cover will annually contribute organic matter to the surface and can greatly reduce erosion. Eventually the soil profile develops into a complete soil ecosystem. The soil bacteria act as an oxygen barrier by consuming oxygen as it enters the soil from the atmosphere. The amount of pollution formed due to oxidation of materials lying below the soil horizon is thus greatly reduced.

A soil profile also tends to act as a sponge by retaining water near the surface. The retained water acts as a surface coolant as it evaporates from the surface. The resulting decrease in surface temperature enhances vegetative growth. Additionally, water retained at the surface or evaporated from the surface does not pass through underlying spoil material, thereby averting potential pollution problems.

Loss of the topsoil is a major hindrance to revegetation and, therefore, topsoil stockpiling is required by OSM. To protect the stockpile from erosion, OSM regulations require that quickgrowing annual and perennial plants be seeded on the pile.

Revegetation can be an entire pollution control plan in some instances, but generally it must be an integral part of more comprehensive plans that incorporate water diversion, overburden segregation, and regrading.

Past revegetation efforts were primarily concerned with planting trees. However, to establish vegetative cover adequately, tree planting must be accompanied by establishment of dense ground covers of grasses and legumes that are compatible with the local plants and local environment. Again, OSM regulations specify many facets of revegetation and reclamation.

Erosion and Sediment Control

The most widely practiced method of erosion control is diversion of water. Diverting streams and surface runoff to avoid contamination from mined or disturbed areas is required by OSM. Diversion involves collection of water before it enters a mine area and conveyance of that water around or through the mine site to a suitable disposal area. Structures used for these purposes include diversion dikes, diversion ditches or swales, diversion pipes, and flumes (4, 5). Flumes and pipes are used mainly in areas of steep terrain or to carry water across regraded areas. A dike, a ridge of compacted soil, is used to simply divert the flow of water, whereas a ditch or diversion system collects the water and transfers it to a suitable disposal area. Erosion can also be controlled by reducing the velocity of the water. This can be done by spreading rip rap over the area, by using check dams, or by using sandbag or straw bale barriers (see Figure X-3). The establishment of vegetation will also decrease erosion damage.

Diversion techniques are directed toward preventing water from entering a mined area. Runoff control employs various methods to handle water after it has reached the mine site. Erosional damage due to runoff can be effectively and inexpensively controlled by the establishment of vegetation. In areas where vegetation cannot be established, rip rap can be used to reduce erosion. Slope reduction and terracing of embankments are also effective in achieving runoff control.

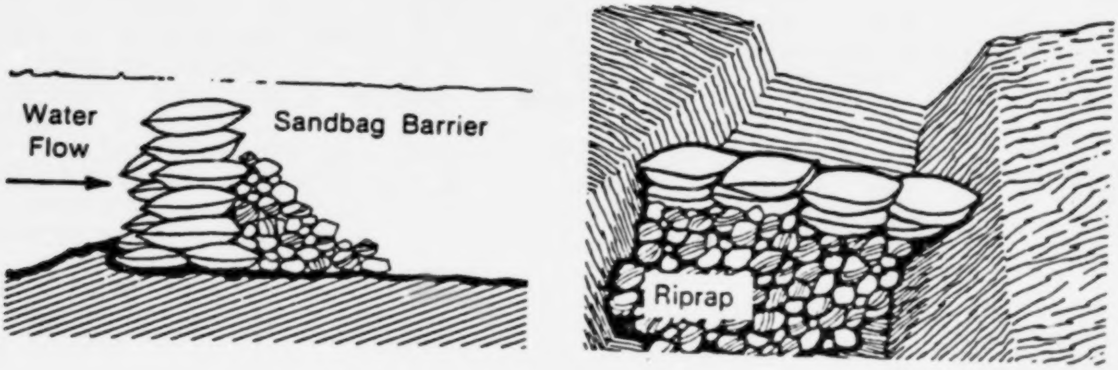
In general, diversion and runoff control methods alone are insufficient to prevent erosion and therefore sedimentation. Methods of sediment control during active mining are needed to remove sediments from the runoff before it is discharged.

The most common method of sediment control is the use of sedimentation ponds. In some cases, certain techniques may be employed to enhance sedimentation pond performance. One such method is the use of straw bale dikes (see Figure X-3). This is a replaceable barrier constructed out of straw bales. The dike intercepts the runoff, reduces the water's velocity, and detains small amounts of sediment (4). Another technique is the use of in-pond baffles to reduce short circuiting and thereby increase retention time.

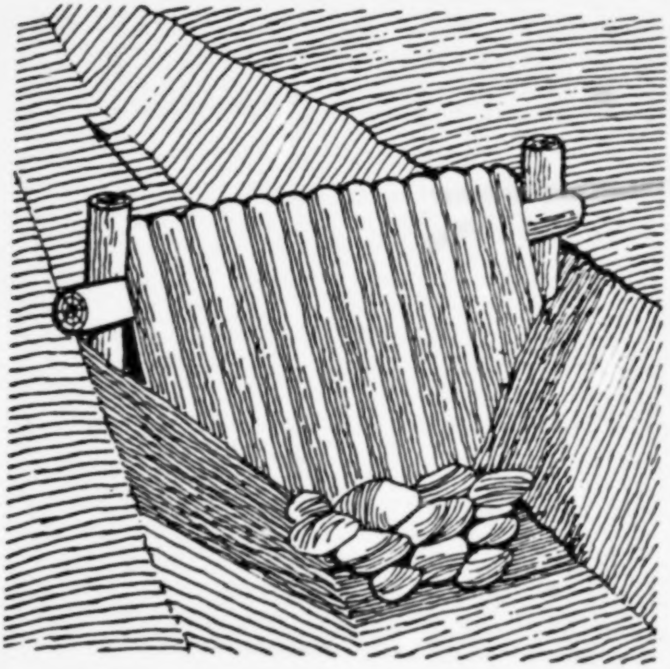
Water Infiltration Control

Control of surface infiltration involves either isolating waste material from the water supply or decreasing the surface permeability. Generally, it is not feasible to isolate the large amounts of waste material generated by mining operations. Also, the waste material may be needed as backfill during regrading operations. Under these conditions, if infiltrating water is causing formation of pollutants, abatement will require on-site control of infiltration such as contained disposal of toxic wastes or decreasing the surface permeability.

Controlling water infiltration from rainfall and subsurface sources can be accomplished by placing impervious barriers on or around the waste material, establishing a vegetative cover, or constructing underdrains. Impervious barriers, constructed of clay, concrete, asphalt, latex, plastic, or formed by special processes such as carbonate bonding, can prevent water from reaching the waste material.



A. SANDBAG BARRIERS

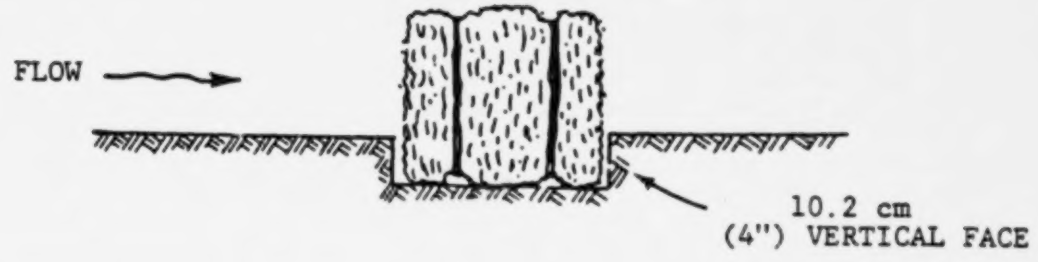


B. LOG CHECK DAM

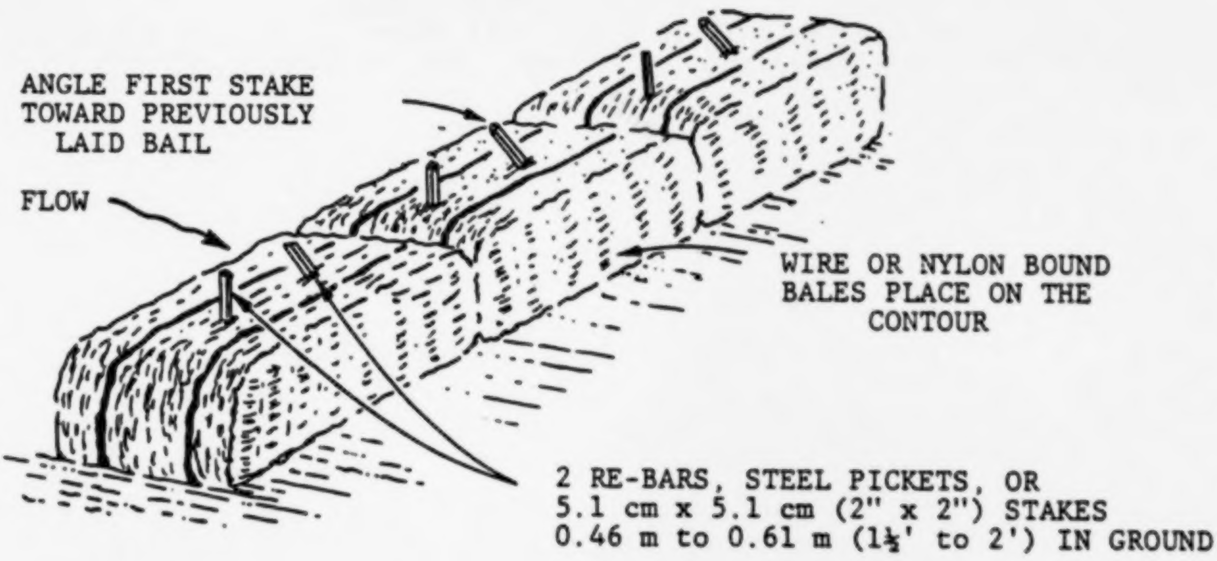
Source: USEPA, Erosion and Sediment Control-Surface Mining in the Eastern U.S., 1976.

Figure X-3

SEDIMENT TRAPS



EMBEDDING DETAIL


ANGLE FIRST STAKE
TOWARD PREVIOUSLY
LAID BAIL
FLOW
WIRE OR NYLON BOUND
BALES PLACE ON THE
CONTOUR
2 RE-BARS, STEEL PICKETS, OR
5.1 cm x 5.1 cm (2" x 2") STAKES
0.46 m to 0.61 m (1½' to 2') IN GROUND

ANCHORING DETAIL

C. STRAW BALE BARRIER

Figure X-3 (Continued)

SEDIMENT TRAPS

A dense vegetative cover has varying effects on infiltration. For instance, vegetation tends to reduce the velocity of water, thereby inducing infiltration. Conversely, a vegetative cover will build up a soil profile, which tends to increase the surface retention of water. This water is available for evaporation and can result in a net decrease in the amount of water entering underlying materials. Vegetation also utilizes large quantities of water in its life processes (again decreasing the amount of water that will reach the underlying material). When infiltration is caused by interception of surface flow, it is usually beneficial to divert the flow. One or more of the techniques illustrated in the erosion and sediment control subsection may be employed for this purpose.

Underdrains are often used to control water infiltration after it has entered the waste material. By offering a quick escape route, contact time between water and any pollutant-forming material contained in the waste is reduced. Also, water flow paths through pollution-forming materials are shortened. The possibility of a fluctuating water table is eliminated. Underdrain discharges should be monitored to determine the nature of pollutants contained therein. Underdrains also serve as collection points to concentrate diffuse groundwater drainage making any required treatment of this wastewater more manageable.

Infiltration can also occur via exploration drillholes or via other holes drilled during mining operations although as previously mentioned, OSM regulations require that these drillholes be cased, sealed or otherwise managed in a manner that avoids drainage into groundwater.

SECTION XI

AMENDMENTS TO NEW SOURCE PERFORMANCE STANDARDS (NSPS)

New source performance standards (NSPS) under Section 306 of the Act are based on the best available demonstrated technology. New mining facilities have the opportunity to implement the best and most efficient coal mining processes and wastewater technologies. Congress, therefore, directed EPA to consider the best demonstrated process changes and end-of-pipe treatment technologies capable of reducing pollution to the maximum extent feasible. New source performance standards were proposed on 13 May 1976 (41 FR 19841) and 19 September 1977 (42 FR 46932) and promulgated on 12 January 1979 (44 FR 2586). The Agency has reviewed these standards and established a number of new options.

NSPS OPTIONS CONSIDERED

General Applicability

The alternate limitations during precipitation events and post-mining discharge limitations apply to all options considered below (the alternate limitations, though do not apply to the zero discharge option for coal preparation plants).

Option One

Require achievement of performance standards in each subcategory based on the same technology proposed for BAT, including neutralization and settling for acidic wastewaters. This option is predicated on application of the same technology proposed for BPT for the acid drainage and preparation plant and associated areas subcategories. The alkaline drainage and areas under reclamation subcategories would be required to meet performance standards based on settling technology. No additional expenditures would be required from selection of this option.

Option Two

Require achievement of performance standards based on flocculant addition. As discussed in Section X, this technology would provide some additional reduction of total suspended solids, but would not provide a cost-effective decrease in toxic pollutant levels, which were found to be extremely low.

Option Three

Require achievement of performance standards based on granular media filtration. As in the case of Option Two, granular media filtration would provide some additional reduction of solids, but would not provide a cost-effective decrease in toxic pollutant levels.

Option Four

Require achievement of no discharge of process wastewater pollutants in the coal preparation plant subcategory with one of the other options selected for the mine drainage subcategories. An occasional purge, subject to BPT limitations, would be allowed when necessary to reduce the concentration of solids or process chemicals in the water circuit to a level which will not interfere with the preparation process or process equipment. Economic and environmental considerations have already provided the incentive to design processes in existing preparation plants which partially or completely reuse process water. The zero discharge requirement would prohibit the discharge of any pollution-bearing streams from the preparation plant water circuit, including the treatment system. No storm exemption would be available.

NSPS SELECTION AND DECISION CRITERIA

EPA has selected Options One and Four as the basis for final new source performance standards. The rationale for selecting Option One was discussed in Section X. In Option Four, the preparation plant subcategory is separated from the associated areas subcategory for new sources. Many existing facilities are practicing total recycle of preparation plant wastewaters, thus zero discharge is a demonstrated technology for these facilities. Further, this option is feasible for new sources because treatment system and water management planning can be implemented from the design phase, eliminating the economic and technical inefficiency associated with retrofitting. Finally, zero discharge removes an average of 35 mg/l (monthly average) of TSS, a parameter regulated under NSPS but not under BAT. Option One will apply to coal mines and coal preparation plant associated areas.

SECTION XII

PRETREATMENT STANDARDS

Section 307(b) of the Act requires EPA to promulgate pretreatment standards for both existing sources (PSES) and new sources (PSNS) of pollution which discharge their wastes into publicly owned treatment works (POTWs). These pretreatment standards are designed to prevent the discharge of pollutants which pass through, interfere with, or are otherwise incompatible with the operation of POTWs. In addition, the Clean Water Act of 1977 adds a new dimension to these standards by requiring pretreatment of pollutants, such as heavy metals, that limit POTW sludge management alternatives. The legislative history of the Act indicates that pretreatment standards are to be technology based and, with respect to toxic pollutants, analogous to BAT. The Agency has promulgated general pretreatment regulations which establish a framework for the implementation of these statutory requirements (see 43 FR 27736, 16 June 1978). EPA is not establishing pretreatment standards for existing sources (PSES) in the coal mining point source category at this time nor does it intend to promulgate such standards in the future (PSNS) since there are no known or anticipated dischargers to publicly owned treatment works (POTWs). Coal mines are located in rural areas, often far from population centers and publicly owned treatment plants. No rational mine operator would choose to route the high volume mine discharge to a POTW for treatment. This is true for existing sources and will continue to be true for new sources, and thus pretreatment standards would be irrelevant and unnecessary.

SECTION XIII

ACKNOWLEDGEMENTS

This document was prepared by Radian Corporation, McLean, Virginia with direction from Mr. Dennis Ruddy and Ms. Allison M. Phillips of the Energy and Mining Branch of the Effluent Guidelines Division of EPA. Direction and assistance were also provided by Mr. William A. Telliard, Chief of the Energy and Mining Branch and Technical Project Officer for this study, and Mr. Matthew Jarrett and Mr. Ron Kirby, Effluent Guidelines Technical Project Monitors. Much of the input for this document was provided by Radian's subcontractors Frontier Technical Associates, Buffalo, New York and Hydrotechnic Corporation, New York, New York. An earlier version of this document was developed and written by Versar Incorporated, Springfield, Virginia. Much of the information developed by Versar was incorporated in this draft. The following agencies and divisions of agencies contributed to the development of this document:

Environmental Protection Agency

1. All regional offices
2. Industrial Environmental Research Laboratory, Cincinnati, Ohio
3. Office of Research and Development
4. Office of General Counsel
5. Office of Analysis and Evaluation
6. Monitoring and Data Support
7. Criteria and Standards division

Pennsylvania Department of Environmental Resources

Bituminous Coal Research

National Coal Association

Many coal companies were very cooperative in providing access to coal mines and coal preparation plants for various sampling and engineering studies. Of particular assistance were:

AMAX Coal Company
Beltrami Enterprises, Incorporated
Beth-Elkhorn Corporation
Bethlehem Mines Corporation
Bill's Coal Company
Buffalo Mining Company

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Central Ohio coal Company
Clemens Coal Company
Consolidation Coal Company
Drummond Coal Company
Duquesne Light Company
Eastern Associated Coal Company
Falcon Coal Company
Harmar Coal Company
Industrial Generating company
Inland Steel Coal Company
Island Creek Coal Company
Jewell Ridge Coal Company
Jones & Laughlin Steel Corporation
Kaiser Steel
Kentland Coal Corporation
King Knob coal Company
Knife River Coal Company
Monterey Coal Company
National Mines Corporation
North American Coal Company
Old Ben coal Company
Peabody Coal Company
Peter Kiewit & Sons, Incorporated
Pittston Coal Company
Southwestern Illinois Coal Company
U.S. Steel
V. & J. Carlson
Washington Irrigation & Development Company
Western Energy Company

SECTION XIV

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SECTION XVI

GLOSSARY

absorption: The process by which a liquid is drawn into and tends to fill permeable pores in a porous solid body; also the increase in weight of a porous solid body resulting from the penetration of liquid into its permeable pores.

acid: A substance which dissolves in water with the formation of hydronium ion. A substance containing hydrogen which may be displaced by metals to form salts.

acid mine drainage (AMD): Synonomous with "ferruginous mine drainage." That drainage which before any treatment has a pH of less than 6.0 or a total iron concentration of more than 10.0 mg/l.

acidity: The quantitative capacity of aqueous solutions to react with hydroxyl ions (OH^-). The condition of a water solution having a pH of less than 7.

acre-foot: A term used in measuring the volume of water that is equal to the quantity of water required to cover 1 acre, 1 foot deep, or 43560 ft^3.

Act: The Federal Water Pollution Control Act, as amended (33 U.S.C. 1251, 1311 and 1314(b) and (c), P.L. 92-500). Also called the Clean Water Act and amendments through 1977.

activated carbon: Carbon which is treated by high-temperature heating with steam or carbon dioxide producing an internal porous particle structure. Activated carbon is often used to adsorb organic pollutants and/or remove metal ions.

active mining area: An area where work or other activity relating to the extraction, removal or recovery of any coal is being conducted. This includes areas where secondary recovery of coal is being conducted, but specifically does not include for surface mines any area of land on or in which grading to return the land to the desired contour has been completed and reclamation work has begun.

Administrator: Administrator of the U.S. Environmental Protection Agency, whose duties are to administer the Act.

adsorption: The adhesion of an extremely thin layer of molecules (of gas, liquid) to the surfaces of solids (granular activated carbons for instance) or liquids with which they are in contact.

alkaline mine drainage: That mine drainage which before any treatment has a pH of more than 6.0 and a total iron concentration of less than 10.0 mg/l.

advanced waste treatment: Any treatment method or process employed following biological treatment (1) to increase the removal of pollution load, (2) to remove substances which may be deleterious to receiving waters or the environment, (3) to produce a high-quality effluent suitable for reuse in any specific manner or for discharge under critical conditions. The term tertiary treatment is commonly used to denote advanced waste treatment methods.

aerated pond: A natural or artificial wastewater treatment pond in which mechanical or diffused air aeration is used to supplement the oxygen supply.

aeration: The bringing about of intimate contact between air and liquid by one of the following methods: spraying the liquid in the air, bubbling air through the liquid (diffused aeration), agitation of the liquid to promote surface absorption of air (mechanical aeration).

agglomeration: The coalesence of dispersed suspended matter into larger flocs or particles which settle more rapidly.

alkalinity: The capacity of water to neutralize acids, a property imparted by the water's content of carbonates, bicarbonates, hydroxides, and occasionally borates, silicates, and phosphates. It is expressed in milligrams per liter of equivalent calcium carbonate.

anion: The charged particle in a solution of an electrolyte which carries a negative charge.

anion exchange process: The reversible exchange of negative ions between functional groups of the ion exchange medium and the solution in which the solid is immersed. Used as a wastewater treatment process for removal of anions, e.g., carbonate.

anthracite: A hard natural coal of high luster which contains little volatile matter, and greater than 92% fixed carbon.

anticline: A fold that is convex upward. The oldest strata are closest to the axial plane of the fold.

aquifer: A subsurface rock formation that is capable of producing water.

areas under reclamation: A previously surface mined area where regrading has been completed and revegetation has commenced.

asbestos minerals: Certain minerals which have a fibrous structure, are heat resistant, chemically inert and possessing high electrical insulating qualities. The two main groups are serpentine and amphiboles. Chrysotile principal commercial variety. Other commercial varieties are armosite, crocidolite, actinolite, anthophyllite, and tremolite.

auger: Any drilling device in which the cuttings are mechanically and continuously removed from the borehole without the use of fluids; usually used for shallow drilling or sampling.

auger mining: Spiral boring for additional recovery of a coal seam exposed in a highwall.

backfilling: The transfer of previously moved material back into an excavation such as a mine or ditch, or against a constructed object.

backwashing: The process of cleaning a rapid sand or mechanical filter by reversing the flow of water.

base: A compound which dissolves in water to yield hydroxyl ions

bench: The surface of an excavated area at some point between the material being mined and the original surface of the ground on which equipment can be set, move or operate. A working road or base below a highwall as in contour stripping for coal.

best available technology economically achievable (BATEA or BAT): The level of technology applicable to effluent limitations to be achieved by July 1, 1984, for industrial discharges to surface waters as defined by Section 301(b) (2) (A) of the Act.

best practicable control technology currently available (BPCTCA or BPT): Treatment required by July 1, 1977 for industrial discharge to surface waters as defined by Section 301(b) (1) (A) of the Act.

best available demonstrated technology (BADT): Treatment rquired for new sources as defined by Section 306 of the Act.

biochemical oxygen demand (BOD): A measure of water contamination expressed as the amount of dissolved oxygen (mg/l) required by microorganisms, during stabilization of organic matter by aerobic chemical action.

bituminous: A coal of intermediate hardness containing between 50 and 92 percent fixed carbon.

blowdown: A portion of water in a closed system which is removed or discharged in order to prevent a buildup of dissolved solids.

carbon absorption: A process utilizing the efficient absorption characteristics of activated carbon to remove both dissolved and suspended substances.

cation: The positively charged particles in solution of an electrolyte.

cationic flocculant: In flocculation, surface active substances which have the active constituent in the positive ion. Used to flocculate and neutralize the negative charge residing on colloidal particles.

chemical analysis: The use of a standard chemical analytical procedure to determine the concentration of a specific pollutant in a wastewater sample.

chemical coagulation: The destabilization and initial aggregation of colloidal and finely divided suspended matter by the addition of a floc-forming chemical.

chemical oxygen demand (COD): A specific test to measure the amount of oxygen required for the complete oxidation of all organic and inorganic matter in a water sample which is susceptible to oxidation by a strong chemical oxidant.

chemical precipitation: (1) Precipitation induced by addition of chemicals. This includes the reaction of dissolved substances such that they pass out of solution into the solids phase. (2) The process of softening water by the addition of lime and soda ash as the precipitants.

clarification: A physical-chemical wastewater treatment process involving the various steps necessary to form a stable, rapid settling floc and to separate it by sedimentation. Clarification may involve pH adjustment, precipitation, coagulation, flocculation, and sedimentation.

clarifier: A basin usually made of steel in which water flows at a low velocity to allow settling of suspended matter.

coagulation: The treatment process by which a chemical added to wastewater acts to neutralize the repulsive forces that hold waste particles in suspension.

coagulants: Materials that induce coagulation and are used to precipitate solids or semi-solids. They are usually compounds which dissociate into strongly charged ions.

coal mine: An area of land with all property placed upon, under or above the surface of such land, used in or resulting from the work of extracting coal from its natural deposits by any means or method including secondary recovery of coal from refuse or other storage piles derived from mining, cleaning, or preparation of coal.

coal mine drainage: Any water drained, pumped or siphoned from a coal mine.

coal pile drainage: Drainage from a coal pile as a result of percolation or runoff from rainfall.

colloids: Suspensions of particles, usually between a nanometer and a micrometer in diameter, in any physical state. In this size range the surface area is so great compared to the volume that unusual phenomenon occur, i.e., particles do not settle out by gravity and are small enough to pass through normal filter membranes (i.e., not ultrafilters).

composite wastewater sample: A combination of individual samples of water or wastewater taken at selected intervals, generally hourly for some specified period, to minimize the effect of the variability of the individual sample. Individual samples may have equal volume or may be roughly proportioned to the flow at time of sampling.

concentration, hydrogen ion: The weight of hydrogen ions in grams per liter of solution. Commonly expressed as the pH value that represents the logarithm of the reciprocal of the hydrogen ion concentration.

conventional pollutants: pH, BOD, fecal coliform, oil and grease, and TSS.

crusher, jaw: A primary crusher designed to reduce the size of materials by impact or crushing between a fixed plate and an oscillating plate or between two oscillating plates, forming a tapered jaw.

crusher, roll: A reduction crusher consisting of a heavy frame on which two rolls are mounted; the rolls are driven so that they rotate toward one another. Coal is fed in from above and nipped between the moving rolls, crushed, and discharged below.

cyclone: (a) The conical-shaped apparatus used in dust collecting operations and fine grinding applications; (b) A classifying (or concentrating) separator into which pulp is fed, so as to take a circular path. Coarser and heavier fractions of solids report as the apex of long cone while finer particles overflow from central vortex.

data correlation: The process of the conversion of reduced data into a functional relationship and the development of the significance of both the data and the relationship for the purpose of process evaluation.

decant structure: Apparatus for removing clarified water from the surface layers of tailings or settling ponds.

deep mine: An underground mine.

dense-media separation: (a) Heavy media separation, or sink float. Separation of heavy sinking from light floating mineral particles in a fluid of intermediate density; (b) Separation of relatively light (floats) and heavy particles (sinks), by immersion in a bath of intermediate density.

denver cell: A flotation cell of the subaeration type, in wide use. Design modifications include receded disk, conical-disk, and multibladed impellers, low-pressure air attachments, and special froth withdrawal arrangements.

denver jig: Pulsion-suction diaphragm jig for fine material, in which makeup (hydraulic) water is admitted through a rotary valve adjustable as to portion of jigging cycle over which controlled addition is made.

dependent variable: A variable whose value is a function of one or more independent variables.

deposit: Mineral, coal or ore deposit is used to designate a natural occurrence of a useful mineral, coal, or an ore, in sufficient extent and degree of concentration to permit exploitation.

depressing agent; depressor; depressant: In the froth flotation process, a substance which reacts with the particle surface to render it less prone to stay in the froth, thus causing it to wet down as a tailing product (contrary to activator).

detention time: The time allowed for solids to collect in a settling tank. Theoretically , detention time is equal to the volume of the tank divided by the flow rate. The actual detention time is determined by operating parameters of the tank.

dewater: To remove a portion of the water from a sludge or a slurry.

differential flotation: Separating a raw coal into two or more coals and pyrites by flotation; also called selective flotation. This type of flotation is made possible by the use of suitable depressors and activators.

discharge: Outflow from a pump, drill hole, piping system, channel, weir or other discernible, confined or discrete conveyance (see also point source).

discharge pipe: A section of pipe or conduit from the condenser discharge to the point of discharge into receiving waters or cooling device.

dispersing agent: Reagent added to flotation circuits to prevent flocculation, especially of objectionable colloidal slimes. Sodium silicate is frequently added for this purpose.

dissolved solids: Theoretically, the anhydrous residues of the dissolved constituents in water. Actually, the term is defined by the method used in determination. In water and wastewater treatment, the Standard Methods tests are used.

disturbed area: An area which has had its natural condition altered in the process of mining coal, preparing coal, or other mine related activities. This includes but is not limited to all areas affected by grubbing and topsoil removal; road construction; construction of mine facilities; coal mining, reclamation and preparation activities; deposition of topsoil, overburden, coal or waste materials, etc. These areas are classified as "disturbed" until said areas have been returned to approximate original contour (or post-mining land use) and topsoil (where appropriate) has been replaced.

dragline: A piece of excavating equipment which employs a cable-hung bucket to remove overburden.

drift: A deep mine entry driven directly into a horizontal or near horizontal mineral seam or vein when it outcrops or is exposed at the ground surface.

effluent: Liquid, such as wastewater, treated or untreated which flows out of a unit operation, reservoir or treatment plant. The influent is the incoming stream.

eluate: Solutions resulting from regeneration (elution) of ion exchange resins.

eluent: A solution used to extract collected ions from an ion exchange resin or solvent and return the resin to its active state.

embankment (or impoundment): Storage basin made to contain wastes from mines or preparation plants.

erosion: Processes whereby solids are removed from their original location on the land surface by hydraulic or wind action.

filter, granular: A device for removing suspended solids from water, consisting of granular material placed in a layer(s) and capable of being cleaned by reversing the direction of the flow.

filter, rapid sand: A filter for the purification of water which has been previously treated, usually by coagulation and sedimentation. The water passes downward through a filtering medium consisting of a layer of sand, prepared anthracite coal or other suitable material, usually from 24 to 30 inches thick and resting on a supporting bed of gravel or other porous medium. The filtrate is removed by an underdrain system. The filter is cleaned periodically by reversing the flow of the water upward through the filtering medium; sometimes supplemented by mechanical or air agitation during backwashing to remove mud and other impurities that are lodged in the sand.

filter, vacuum: A filter consisting of a cylindrical drum mounted on a horizontal axis, covered with a filter cloth revolving with a partial submergence in liquid. A vacuum is maintained under the cloth for the larger part of a revolution to extract moisture and the cake is scraped off continuously.

filtration: The process of passing a liquid through a filtering medium for the removal of suspended or colloidal matter.

final contour: The surface shape or contour of a surface mine (or section thereof) after all mining and earth moving (regrading) operations have been completed.

fine: Fines is a term that refers to the size of a particle. They are approximately between -100 and -200 mesh.

floc: A very fine, fluffy mass formed by the aggregation of fine suspended particles.

flocculants: Any substance which will cause flocculation. They are specifically useful in wastewater treatment. Lime, alum, and ferric chloride are examples of inorganic flocculants and polyelectrolytes are organic flocculants.

flocculate: To cause to aggregate or to coalesce into small lumps or loose clusters, e.g., the calcium ion tends to flocculate clays.

flocculation: In water and wastewater treatment, the agglomeration of colloidal and finely divided suspended matter after coagulation by gently stirring by either mechanical or hydraulic means.

flotation: The method of coal or mineral separation in which a froth created in water by a variety of reagents floats some finely crushed coal or minerals, whereas pyrites and other minerals sink.

flotation agent: A substance or chemical which alters the surface tension of water or which makes it froth easily. The reagents used in the flotation process include pH regulators, slime dispersants, resurfacing agents, wetting agents, conditioning agents, collectors, and frothers.

flume: An open channel or conduit on a prepared grade.

froth, foam: In the flotation process, a collection of bubbles resulting from agitation, the bubbles being the agenct for raising (floating) the particles of coal or ore to the surface of the cell.

frother(s): Substances used in flotation processes to make air bubbles sufficiently permanent principally by reducing surface tension. Common frothers are pine oil, creyslic acid, and amyl alcohol.

flow model: A mathematical model of the effluent wastewater flow, developed through the use of multiple linear regression techniques.

flow rate: Usually expressed as liters/minute (gallons/minute) or liters/day (million gallons/day). Design flow rate is that used to size the wastewater treatment process. Peak flow rate is 1.5 to 2.5 times design and relates to the hydraulic flow limit and is specified for each plant. Flow rates can be mixed as batch and continuous where these two treatment modes are used in the same plant.

frequency distribution: An arrangement or distribution of quantities pertaining to a single element in order of their magnitude.

grab sample: A single sample of wastewater taken at neither a set time nor flow.

gravity separation: Treatment of coal or mineral particles which exploits differences between their specific gravities. Their sizes and shapes also play a minor part in separation. Performed by means of jigs, classifiers, hydrocyclones, dense media, shaking tables, Humphreys spirals, sluices, vanners and briddles.

grinding: (a) Size reduction into relatively fine particles. (b) Arbitrarily divided into dry grinding performed on coal or mineral containing only moisture as mined, and wet grinding, usually done in rod, ball or pebble mills with added water.

groundwater table (or level): Upper surface of the underground zone of saturation.

grout: A fluid mixture of cement, sand (or other additives) and water that can be poured or pumped easily.

hardness: A characteristic of water, imparted by salts of calcium, magnesium, and iron, such as bicarbonates, carbonates, sulfates, chlorides, and nitrates, that causes curdling of soap, deposition of scale in boilers, damage in some industrial process, and sometimes objectionable taste. It may be determined by a standard laboratory procedure or computed from the amounts of calcium and magnesium as well as iron, aluminum, manganese, barium, strontium, and zinc, and is expressed as equivalent calcium carbonate.

heavy-media separation: See dense-media separation.

highwall: The unexcavated face of exposed overburden and coal in a surface mine or the face or bank on the uphill side of a contour strip mine excavation.

hydrocyclone: A cyclone separator in which a spray of water is used.

hydroclassifier: A machine which uses an upward current of water to remove fine particles from coarser material.

hydrology: The science that relates to the water systems of the earth.

independent variable: A variable whose value is not dependent on the value of any other variable.

influent: The liquid, such as untreated or partially treated wastewater, which flows into a reservoir, process unit, or treatment plant. The effluent is the outgoing stream.

in-plant control: Those treatment techniques that are used to reduce, reuse, recycle, or treat wastewater prior to end-of pipe treatment.

ion: A charged atom, molecule or radical, the migration of which affects the transport of electricity through an electrolyte.

ion exchange: A chemical process involving reversible interchange of ions between a liquid and solid but no radical change in the structure of the solid.

jig: A machine in which the feed is stratified in water by means of a pulsating motion and from which the stratified products are separately removed, the pulsating motion being usually obtained by alternate upward and downward currents of the water. jigging: A process used to separate coarse materials in the coal or ore by means of differences in specific gravity in a water medium.

lagoon: Man-made ponds or lakes usually 4 feet deep (or up to 18 feet if aerated) which are used for storage, treatment, or disposal of wastes. They can be used to hold wastewater for removal of suspended solids, to store sludge, cool water, or for stabilization of organic matter by biological oxidation. Lagoons can also be used as holding ponds, after chemical clarification and to polish the effluent.

lignite: A carbonaceous fuel ranked between peat and bituminous coal.

lime: Any of a family of chemicals consisting essentially of calcium hydroxide made from limestone (calcite) which is composed almost wholly of calcium carbonate or a mixture of calcium and magnesium carbonates.

lime slurry: A form of calcium hydroxide in aqueous suspension that contains free water.

linear regression: A method to fit a line through a set of points such that the sum of squared vertical deviations of the point values from the fitted line is a minimum, i.e., no other line, no matter how it is computed, will have a smaller sum of squared distances between the actual and predicted values of the dependent variable.

magnetic separator: A device used to separate magnetic from less magnetic or nonmagnetic materials.

mathematical model: A quantitative equation or system of equations formulated in such a way as to reasonably depict the structure of a situation and the relationships among the relevant variables.

mean value: The statistical expected or average figure.

median value: A data observation located at the 50th percentile or the midrange.

mesh size (activated carbon): The particle size of granular activated carbon as determined by the U.S. Sieve series. Particle size distribution within a mesh series is given in the specification of the particular carbon.

milligrams per liter (mg/l): This is a mass per volume designation used in water and wastewater analysis.

minable: (a) Capable of being mined. (b) Material that can be mined under present day mining technology and economics.

mine: (a) An opening or excavation in the earth for the purpose of excavating minerals, coals, metal ores or other substances by digging. (b) A word for the excavation of minerals by means of pits, shafts, levels, tunnels, etc., as opposed to a quarry, where the whole excavation is open. In general the existence of a mine is determined by the mode in which the mineral is obtained, and not by its chemical or geologic character. (c) An excavation beneath the surface of the ground from which mineral matter of value is extracted.

mine drainage: Mine drainage usually implies gravity flow of wastewater from coal mining to a point away from the mining operation. However, this term encompasses any wastewater emanating from a coal mining or preparation operation.

mixed-media filtration: A filter which uses two or more filter materials of differing specific gravities selected so as to produce a filter uniformly graded coarse to fine.

mulching: The addition of materials (usually organic) to the land surface to curtail erosion or retain soil moisture.

multiple linear regression: A method to fit a plane through a set of points such that the sum of squared distances between the individual observations and the estimated plane is a minimum. This statistical technique is an extension of linear regression in that more than one independent variable is used in the least squares equation.

neutralization: Adjustment of pH by the addition of acid or alkali until a pH of about 7.0 is achieved. See pH adjustment.

new source: Any point source, the construction of which is begun after the publication of proposed Section 306 regulations.

new source performance standard (NSPS): Performance standards for the industry and applicable new sources as defined by Section 306 of the Act.

NPDES permits: National Pollutant Discharge Elimination System Permits are issued by the EPA or an approved state program in order to regulate point-source discharge to public waters.

nonconventional pollutants: Chemical or thermal pollutants, principally defined by not being a conventional or toxic pollutant.

normalized coefficients: Regression constants whose magnitudes are referenced to some value.

open-pit mining, open cut mining: A form of operation designed to extract coal or minerals that lie near the surface. Waste, or overburden, is first removed, and the coal or mineral is broken and loaded.

osmosis: The process of diffusion of a solvent through a semipermeable membrane from a solution of lower to one of higher solute concentration.

osmotic pressure: The equilibrium pressure differential across a semipermeable membrane which separates a solution of lower from one of higher concentration.

outcrop: The exposing of bedrock or strata projecting through the overlying cover of detritus and soil.

outfall: The point or location where sewage or drainage discharges from a sewer, drain or conduit.

overburden: Material of any nature, consolidated or unconsolidated, that overlies a deposit of useful materials (i.e., coal, ores, etc.).

overflow: Excess water discharged from the treatment system.

oxidation: The addition of oxygen to a chemical compound, or any reaction which involves the loss of electrons from an atom.

oxidized zone: In coal mining, that portion of a refuse pile near the surface, which has been leached by percolating water carrying oxygen, carbon dioxide or other gases.

permeability: Capacity for transmitting a fluid.

pH: A measure of the acidity or alkalinity of an aqueous solution, generally expressed in terms of the hydrogen ion considered an acidic solution; and above 7 it is considered an alkaline solution.

pH adjustment: Treatment of wastewater by the addition of an acid or alkali to effect a change in the pH or hydrogen ion concentration. Alkalis such as lime (CaO), limestone ($CaCO_3$), caustic soda (NaOH), or soda ash (Na_2CO_3), which supply hydroxyl ions are used to adjust acidic streams while an acid, usually sulfuric (H_2SO_4) or hydrochloric (HCl) reacts with alkaline streams by supplying hydrogen ions. The pH of an effluent is adjusted to a range of 6 to 9 to make it suitable for discharge.

pH modifiers: Proper functioning of a cationic or anionic flotation reagent is dependent on the close control of pH. Modifying agents used are soda ash, sodium hydroxide, sodium silicate, sodium phosphates, lime, sulfuric acid, and hydrofluoric acid.

pH value: A scale for expressing the acidity or alkalinity of a solution. Mathematically, it is the logarithm of the reciprocal of the gram ionic hydrogen equivalents per liter. Neutral water has a pH of 7.0 and hydrogen ion concentration of 10^{-7} moles per liter.

physical-chemical treatment: In this study, it is taken to mean a method of treating wastewater by the addition of chemicals to physically separate the pollutant from a stream, usually by precipitation, followed by settling or flotation of the wastes. To accomplish this, several processes may be utilized such as pH adjustment, reduction of hexavalent chromium, heavy-metal precipitation, coagulation, flocculation, and clarificaiton by settling.

point source: Any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged.

preparation plant: A facility that cleans, sizes and upgrades run-of-mine coal thereby creating a final coal product prior to shipping or consumption, and facilities (i.e., slurry pond, fresh water pond, conveyances) directly associated with the recycling or discharge of waters used during the "preparation" of coal.

preparation plant ancillary or associated areas: Areas that are interrelated with coal preparation or coal load out activities but do not include the preparation plant building and the preparation plant water recycle/discharge system. Said areas include but are not limited to ancillary buildings associated with coal preparation; disturbed areas in proximity to the preparation plant or related preparation activities; coal stockpiles; coal refuse storage areas; coal haulroads and refuse haulroads in proximity to the preparation plant or coal refuse storage site; treatment systems designed to handle runoff or seepage from preparation plant "disturbed" areas, or coal refuse piles etc.

priority pollutants: Those pollutants included in Table 1 of Committee Print Numbered 95-30 of the "Committee on Public Works and Transportation of the House of Representatives," subject to the Clean Water Act of 1977, and included in Table VI-1 of this document.

pyrites: Mineral group composed of iron and sulfur found in coal rank of coal: A classification of coal based upon the fixed carbon on a dry weight basis and the heat value.

raw mine drainage: Untreated or unprocessed water drained, pumped or siphoned from a mine.

reagent: A chemical or solution used to produce a desired chemical reaction; a substance used in flotation.

reclamation: The procedures by which a disturbed area can be reworked to make it productive, useful, or aesthetically pleasing, consisting primarily of regrading and revegetation.

reduction: A chemical reaction which involves the addition of electrons to a species.

refuse pile: Waste material from a preparation plant. The material includes pyrites, ash, and water or chemicals used in cleaning the coal.

regression model: A mathematical model, usually a single equation, developed through the use of a least squares linear regression analysis.

reserve: That part of an identified resource from which a usable mineral and energy commodity can be economically and legally extracted at the time of determination.

residuals: The differences between the expected and actual values in a regression analysis.

reverse osmosis: The process of diffusion of a solvent through a semipermeable membrane from a solution of higher to one of lower solute concentration, effected by raising the pressure of the more concentrated solution to above the osmotic pressure.

riprap: Rough stone of various sizes placed compactly or irregularly to prevent erosion.

room and pillar mining: A system of mining in which the distinguishing feature is the mining of 50 percent or more of the coal in the first working. The coal is mined in rooms separated by narrow ribs (pillars); the coal in the pillars can be extracted by subsequent working in which the roof is caved in successive blocks.

runoff: That part of precipitation that flows over the land surface from the area upon which it falls.

sampler: A device used with or without flow measurement to obtain any adequate portion of water or waste for analytical purposes. May be designed for taking a single sample (grab),composite sample, continuous sample, or periodic sample.

sampling stations: Locations where several flow samples are tapped for analysis.

scarification: The process of breaking up the topsoil prior to mining.

sediment: Solid material settled from suspension in a liquid medium.

sedimentation: The gravity separation of settleable, suspended solids in a settling basin or lagoon.

settleable solids: (1) That matter in wastewater which will not stay in suspension during a preselected settling period, such as 1 hour but either settles to the bottom or floats to the top. (2) In the Imhoff cone test, the volume of matter that settles to the bottom of a 1-liter cone in 1 hour.

Settlement Agreement of June 7, 1976: Agreement between the U.S. Environmental Protection Agency (EPA) and various environmental groups, as instituted by the United States District Court for the District of Columbia, directing the EPA to study and promulgate regulations for a list of chemical substances, referred to as Appendix A Pollutants.

settling pond: A pond, natural or artificial, for recovering solids from an effluent.

significance: A statistical measure of the validity, confidence, and reliability of a figure.

sludge: Accumulated solids separated from a liquid during processing.

sluice: To cause water to flow at high velocities for wastage, for purposes of excavation, ejecting debris, etc.

slurry: Solid material conveyed in a liquid medium.

spoil material: Overburden that is removed from above the coal seam; usually deposited in previously mined areas.

statistical variance: The sum of the squared deviations about the mean value in proportion to the likelihood of occurrence. A measure used to identify the dispersion of a set of data.

subsidence: Surface depression created by caving of the roof material in an underground mine.

sump: Any excavation in a mine for the collection of water for pumping.

suspended solids: (1) Solids which either float on the surface of or are in suspension in water, wastewater, or other liquids, and which are removable by a .45 micron filter. (2) The quantity of material removed from wastewater in a laboratory test, as prescribed in "Standard Methods for the Examination of Water and Wastewater" and referred to as nonfilterable residue, measured in mass per unit volume (e.g., mg/l).

surface active agent: One which modified physical, electrical, or chemical characteristics of the surface of solids and also surface tensions of solids or liquid. Used in froth flotation (see also depressing agent, flotation agent).

syncline: A fold that is concave upward. The younger strata are closest to the axial plane of the fold.

table, air: a vibrating, porous table using air currents to effect gravity concentration of sands or other waste material from coal.

terracing: The act of creating horizontal or near horizontal benches.

thickener: A vessel or apparatus for reducing the amount of water (or conversely, increasing the concentration of settled material) in a wastewater stream.

tolerance limits: Numerical values identifying the acceptable range of some variable.

turbidity: Is a measure of the amount of light passing through a volume of water, which is directly related to the suspended solids content.

weir: An obstruction placed across a stream for the purpose of diverting the water so as to make it flow through a desired channel, which may be an opening or notch in the weir itself.

yellowboy: Salt of iron and sulfate formed by treating acid mine drainage (AMD) with lime; $FeSO_4$.

ABBREVIATIONS

Ag	Silver
Al	Aluminum
As	Arsenic
BADT	Best Available Demonstrated Technology
BATEA (BAT)	Best Available Technology Economically Achievable
BCPCT (BCT)	Best Conventional Pollutant Control Technology
Be	Beryllium
BMP	Best Management Practices
BOD	Biochemical Oxidation Demand
BPCTCA (BPT)	Best Practicable Control Technology Currently Available
Ca	Calcium
Cd	Cadmium
CN	Cyanide
COD	Chemical Oxygen Demand
Cr	Chromium
Cu	Copper
CWA	Clean Water Act of 1977
DM	Dissolved Metals
EPA	Environmental Protection Agency
Fe	Iron
FWPCA	Federal Water Pollution Control Act of 1972
Hg	Mercury
Mg	Magnesium
Mn	Manganese
Na	Sodium
Ni	Nickel
NPDES	National Pollution Discharge Elimination System
NSPS	New Source Performance Standards
OSM	Office of Surface Mining (Reclamation and Enforcement)
Pb	Lead
POTW	Publicly Owned Treatment Works
PSES	Pretreatment Standards for Existing Sources
PSNS	Pretreatment Standards for New Sources
RCRA	Resource Conservation and Recovery Act of 1976
Sb	Antimony
Se	Selenium
SMCRA	Surface Mining Control and Reclamation Act of 1977

SS	Settleable Solids
TDS	Total Dissolved Solids
Tl	Thallium
TM	Total Metals
TS	Total Solids
TSS	Total Suspended Solids
Zn	Zinc

Units

FTU	Franklin Turbidity Unit
JTU	Jackson Turbidity Unit
kkg	thousand kilograms
mgd	million gallons per day
mg/l	milligram(s) per liter
ml/l	mililiter(s)/liter
ug/l	microgram(s)/liter
mty	million tons per year
ppb	part(s) per billion
ppm	part(s) per million
t	ton
NTU	Nephelometric Turbidity Unit

APPENDIX A

COAL MINING INDUSTRY SELF MONITORING PROGRAM

INTRODUCTION

This appendix consists of the following three reports all concerning the results of the 308 industry self-monitoring survey:

1) "Coal Mining Industry Self-Monitoring Program" by Radian Corporation, 1981.

2) "Reassessment of the Self-Monitoring Data Base According to the Amended 10-Year, 24-Hour Pond Design Volume for Coal Mines", by EPA, 1982.

3) "Statistical Support for the Proposed Effluent Limitation of 0.5 ml/l for Settleable Solids in the Coal Mining Industrial Category", by EPA, 1982.

The first report summarizes and evaluates the data obtained from an industry self-monitoring survey. This evaluation determined that 0.5 ml/l settleable solids was an appropriate effluent limitation for reclamation areas and for active mines during storms equal to or less than the 10-year, 24-hour precipitation event. The technology on which this effluent limitation was based was a 10-year, 24-hour pond as defined in the January 13, 1981 proposal to the coal mining industry. The language in this proposal required that the treatment facility's design, construction, operation, and maintenance be based upon water draining into it, including waters from the undisturbed (virgin) area and inactive (reclaimed) area, in addition to the active mining area. Twenty-four ponds submitted data in this survey, 7 of which were determined to be 10-year, 24-hour ponds. The analysis upon which the 0.5 ml/l limitation was established was based, though, on 6 of these 7 ponds because one was considered to be improperly operated and designed.

The January 13, 1981 proposal was amended on May 26, 1981. This amendment modified the design volume of a pond by excluding from consideration waters from undisturbed areas which drain into the treatment facility. The data base submitted by the 24 ponds was therefore reevaluated and it was determined that eleven rather than six ponds were 10-year, 24-hour ponds according to the new definition. The second report presents the calculations and results of this reevaluation.

The third report presents the statistical evaluation performed on the data submitted by these eleven 10-year, 24-hour ponds which determined that 0.5 ml/l is within EPA's 99th percentile criterion for establishing effluent limitations.

REPORT 1

COAL MINING INDUSTRY
SELF-MONITORING PROGRAM

May 1981

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1.0 INTRODUCTION

On 12 January 1979, EPA (the Agency) proposed areas under reclamation as a separate subcategory for establishment of effluent limitations. Also, the Agency published, during the spring and summer of 1979, a number of notices in the Federal Register regarding a storm relief provision for sedimentation ponds at coal mines. Both areas were reserved pending further data base development. To augment the data bases for these two areas, the Agency instituted two studies.

The first is a currently ongoing study jointly sponsored with the Office of Surface Mining, Reclamation and Enforcement (OSM). Approximately 39 mine sites have been identified for a survey of reclamation and sediment control techniques, including sediment pond performance. Eight sites have been designated for more intensive study and sample collection. As data from this study become available, the results will be evaluated.

The second study is the subject of this report. EPA is granted authority under Section 308 of the Clean Water Act Amendments of 1977 to "require the owner or operator of any point source to . . . install, use, and maintain monitoring equipment or methods . . . and sample effluents (in accordance with such methods, at such locations, at such intervals, and in such manner as the Administrator shall prescribe)" for the purpose of developing effluent limitations under the Act. The Agency utilized this authority in establishing an industry self-monitoring survey at 23 mine reclamation ponds around the country.

The results of both these studies will be used to establish actual pond performance data and, ultimately, to form part of the basis for development of effluent limitations for areas under reclamation and for storm events. A summary and the

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conclusions are presented in Section 2.0. Background information for the study is presented in Section 3.0, and the analytical data and a discussion of the results are presented in Section 4.0.

2.0 SUMMARY AND CONCLUSIONS

The data collection portion of this study commenced in September 1979 and concluded in September of 1980. The set of instructions for each industry participant appears in Appendix A. Industry participants were requested to submit design criteria, a topographic map, and a photograph or slide for each pond. In addition, samples collected during each month were to be analyzed by the participants for total suspended solids, settleable solids, total and dissolved iron, and pH by EPA-approved analytical methods. These data with pertinent rainfall information were to be submitted to EPA on a monthly basis. Also, certain samples were to be split and one of the splits transported to EPA analytical laboratories in Denver, Colorado. In Denver, the samples were analyzed for iron, manganese, and the 13 toxic metals. After the first six months' results from these split samples were received, continuation of this part of the program was deemed unnecessary and was terminated in April 1980.

As shown in Table 2-1, industry compliance was scattered, with some facilities providing all requested information and others providing little. The gaps in the data rendered consistent analyses more difficult. Moreover, data submitted on monthly reporting sheets by certain facilities were sometimes incomplete or incorrectly reported. Certain facilities (182 and 192) could not provide samples because no discharge occurred. These facilities are located in the West where more arid conditions prevail or where extended periods of freezing temperatures are common.

Nineteen ponds provided data for analysis of toxic metals and settleable and suspended solids. Reviewing the design information, seven of these 19 were adequately sized to handle the runoff from a 10-year, 24-hour storm. Subsequent analysis

TABLE 2-1

SUMMARY OF INDUSTRY RESPONSES AND DATA SUBMITTALS

				Monthly Data Submittals													
				1979													
Facility	Pond	Design Information Submitted?	Discharged?	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
15	1	Yes	Yes	X O	X O	X O	X	O	O	X	X	X	X	X	X		
15	2	Yes	Yes	X O	X O	X O	X O		O	X	X	X	X	X	X		
25	3*	No	Yes				X O	X O	X O								
25	4	Yes	Yes						X	X O	X	X	X	X	X		
25	7	Yes	Yes				X	X	X	X	X	X	X	X	X		
33	1	Yes	Yes			X O	X O	X O	X O	X O	X	X	X	X	X		
35	2	Yes	Yes			X O	X O	X O	X O	X	X	X	X	X	X		
37	6	Yes	Yes		X O	X O	X O	X O	X O	X	X	X	X	X	X		
38	19	Yes	Yes					X O	X	X	X	X	X				
85	1	Yes	Yes	X	X O	X O	X O	X O	X O	X O	X	X	X				
101	2	Yes	Yes	X	X O	X O	X O	X O	X O	X O	X	X	X				
123	3	Yes	Yes				X O	X O	X O	X O	X	X	X				
181	99	Yes	Yes		X O	X O	X O	X O	X					X		X	X
182	1	Yes	No														
182	2	Yes	No														

TABLE 2-1 - Continued

SUMMARY OF INDUSTRY RESPONSES AND DATA SUBMITTALS

				Monthly Data Submittals													
				1979													
Facility	Pond	Design Information Submitted?	Discharged?	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV
183	1	Yes	Yes	X	X O	X O	X O	X O	X O	X O	X	X	X	X	X		
184	7	Yes	Yes	X	X O	X O	X O	X O	X O		X	X	X	X	X		
185	4	Yes	Yes	X	X O	X O				X	X	X	X	X			
186	2	Yes	Yes	X	X O	X O	X O	X O	X O		X	X	X	X	X		
187	1	Yes	Yes	X	X O	X O	X O	X O	X O		X	X	X	X	X		
191	55	Yes	Yes			X O	X O	X O	X O	X	X	X	X	X			
191	18	Yes	Yes			X O	X O	X O	X O	X	X	X	X	X			
192	4	Yes	No														
192	6	Yes	No														

X - Data supplied by industry.
O - Data supplied by EPA laboratories.
* - Pond 3 was replaced by pond 4 at facility 25 in March 1980.

showed one of these, pond 1 at facility 101, to be poorly designed in other aspects. These screening procedures thus yielded six ponds that were properly designed to contain the 10-year, 24-hour event, and 13 that were not.

Results from the study support the following conclusions:

- Toxic metals were not found in concentrations in pond effluents significantly above their limit of detection;
- Variations in total suspended solids in influent streams appear to depend on differences in weather conditions, drainage area size, soil type, ground cover, degree of reseeding, and other site-specific factors;
- Pond performance is closely linked with design and operation;
- The data indicated that, on a daily basis, total suspended solids of 70 mg/l in reclamation area discharges cannot be consistently achieved, especially during rainfall events;
- Settleable solids effluent values were reported at zero or not detectable levels in 92 percent and 81 percent of the reported cases for dry and wet conditions, respectively;
- Settleable solids detection limit was reported as 0.1 ml/l in over 93 percent of the cases where a "not detected" value was recorded, i.e., <0.1 ml/l;
- A daily maximum limitation of 0.5 ml/l represents an achievable settleable solids limitation; pond volume was found to be a relevant factor in achieving this limitation. All ponds in this study with proper design and volume large enough to contain the 10-year, 24-hour storm always achieved the 0.5 ml/l settleable solids limitation regardless of any other factors, including weather; and

- Although only four to six of the facilities treated active area drainage (e.g., pit pumpage) in the ponds, in every case during rainfall these ponds achieved the 0.5 ml/l settleable solids limitation. Based on the data received to date, active area sedimentation facilities could also consistently achieve the 0.5 ml/l settleable solids limitation during periods of rainfall less than the 10-year, 24-hour storm.

3.0 SAMPLING AND ANALYSIS PROGRAM

3.1 Self-Monitoring Study

The purposes of this study include:

(1) Establish data for regulation development within the reclamation subcategory

(2) Augment current data on sedimentation pond performance

(3) Link pond performance to pond design

(4) Establish data on pond performance during and immediately after precipitation events.

To assemble a representative data base, the coal mining industry was reviewed for the number of facilities where reclamation is occurring. There are some 2,600 surface mines currently in operation, so this represents the target population. Most of these mines are very small, with no full time environmental or water management staff. It is doubtful that sufficient personnel and laboratory resources would be available at these small mines for participation in this program. Therefore, the focus of the study was on surface mines operated by large, well established mining companies.

To select the facilities, the mines were screened according to the following criteria:

- Location
- Topography
- Existence of ponds serving reclamation areas
- Sufficient resources to conduct program
- Cost to industry participants
- Participation and cooperation of facility and/or mining company in previous EPA studies.

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These criteria were applied in conjunction with EPA and its contractor's knowledge of the candidate facilities, and in consultation with the industry trade association, the National Coal Association. One additional constraint was the available time for collection, analysis, and reporting of the data, since the Agency is subject to schedules for regulatory proposals established by the Clean Water Act and the 1976 Consent Decree.

This process resulted in the selection of 23 ponds at 17 separate facilities. Although this is a small percentage of the total population, the results and conclusions can be reliably applied to the other mining facilities. This is because the variation of sediment load to any one pond over the period of a year is much greater than the variation from pond to pond. Thus the large majority of potential conditions that could be expected at a surface mine will have been encountered during the course of this study.

Twelve coal mining companies owning the 17 facilities were contacted in September 1979. Two of the facilities were reported to have little or no discharge during the study, and thus were excluded from further participation. Facility personnel sampled on a weekly basis the influent and effluent to each pond. Additional samples were collected the day of a rainfall event and the day after the event. Flow rate of the discharge was measured or estimated at the time of sampling. To correlate the data with the pond design, the Agency also requested that each company submit design data for each pond being monitored. An example of the data request form sent to each company may be found in Appendix A.

3.2 Facilities Sampled

A total of 19 ponds were sampled at 15 facilities. These ponds primarily receive runoff from virgin areas (acreage where no disturbance by the mining company has occurred) and areas under reclamation (areas that have been regraded and revegetated). The mine locations, number of ponds sampled, and facility codes are listed in Table 3-1.

3.3 Analysis Program

The samples collected by each participant were analyzed by the participant for the following parameters:

- Total suspended solids
- Settleable solids
- pH
- Total iron
- Dissolved iron.

Some samples were split, with one of the splits sent to EPA Denver laboratories. These split samples were given a code number by the company to permit matching of the samples after analyses were completed.

The EPA laboratory analyzed each sample for the following parameters:

- Total suspended solids
- Total iron
- Total manganese
- Dissolved iron

Table 3-1

FACILITIES SAMPLED

Location	Number of Ponds	Mine Code Number
Pennsylvania	1	186
Pennsylvania	1	187
West Virginia	2	15
West Virginia	1	183
West Virginia	1	184
West Virginia	1	185
Kentucky	1	38
Kentucky	1	181
Ohio	2-3[1]	25
Ohio	1	101
Indiana	2	33
Illinois	1	37
Illinois	1	85
Illinois	1	123
Alabama	2	191
Montana[2]	2	182
Wyoming[2]	2	192
	23	

[1] Facility 25 substituted one of the ponds sampled midway through the study.

[2] These facilities apparently had little or no discharge of water during the study.

- Dissolved manganese
- Total and dissolved toxic metals, including

  --antimony
  --arsenic
  --beryllium
  --cadmium
  --chromium
  --copper
  --lead
  --mercury
  --nickel
  --selenium
  --silver
  —thallium
  --zinc.

The metals were analyzed by inductively-coupled argon plasma spectroscopy (ICAP).

Monthly reports were submitted to the Effluent Guidelines Division on forms provided by the Agency. An example of this form is provided in Appendix A.

3.4 Pond Design Data

The Agency requested the companies to provide design data, a topographic map, and photographs for each pond included as a part of this study. These design parameters can be linked to performance of the pond, both in the long-term and for shock loads resulting from, for example, storm runoff. The form used to request this information may also be found in Appendix A. Major design parameters requested include:

- Drainage area acreage
  --virgin
  --disturbed
- Average slope of drainage area
- Type of soil and cover

- Surface area, average depth, and volume of sedimentation pond.
- Design and occupied sediment storage volume
- Design detention time
- Dewatering device
- Embankment height and width.

The last five of these design factors had corresponding criteria promulgated on 13 March 1979 by the Department of the Interior's Office of Surface Mining, Reclamation, and Enforcement (OSM) under authority of the Surface Mining Control and Reclamation Act of 1977 (SMCRA). On 31 December 1979, OSM suspended certain of these design criteria pending further study. In part, these were the specific standards for minimum sediment storage volume and minimum hydraulic detention time. However, the basic requirement that the pond be adequately sized to hold the undiverted water resulting from a 10-year, 24-hour precipitation event remained intact. For the purposes of this study, the suspended OSM criteria were examined to allow a first assessment of pond design. The consistent use of this uniform set of criteria for all ponds also permitted comparisons between ponds in terms of achievable effluent quality. The OSM criteria and requirements are discussed below.

Surface Area, Average Depth, and Volume of the Pond

Only the volume of the pond is regulated. It must be sized to hold the runoff resulting from a 10-year, 24-hour precipitation event.

Sediment Storage

Minimum sediment storage allowable in a pond is either three years of sediment computed by using accepted methods, or 0.1 acre-feet of sediment per acre of disturbed land. If on-site control methods such as check dams and grass filters can be shown to limit sediment delivery from the disturbed land, sediment storage as low as 0.035 acre-feet of sediment per acre of disturbed land can be used if approved by the regulatory authority. Further, sediment must be removed from the pond when 60 percent of the design storage volume has been occupied.

Design Detention Time

Minimum theoretical detention time to be provided by sedimentation ponds is 24 hours for a 10-year, 24-hour event. A detention time as low as 10 hours may be approved if any or all of the following techniques or conditions are used and are shown not to reduce pond efficiency:

(a) Improved pond design

(b) Special sediment characteristics occur

(c) Chemical treatment is used.

Dewatering Device

A dewatering device must be used to remove the detained water in the designed time period and must always remain above the sediment storage level.

Embankment Height and Width

The embankment top must be at least 1.0 foot above the maximum water level during a 25-year, 24-hour precipitation event. The top width of the embankment must be at least (H + 35)/5, where H is the height in feet from the upstream toe to the top.

The design data submitted by the companies are presented in detail in the next section.

4.0 RESULTS

In this section the pond design data submitted by each company are presented and discussed. The analytical results from the industry sampling program are also tabulated and linked to pond design.

4.1 Pond Design Data

Incomplete information was often submitted by the industry participants regarding pond design factors. The available data are summarized in Table 4-1. In general, the results show that the ponds are in compliance with most of the OSM standards. Fourteen ponds, however, did not provide the OSM design storage volume for the runoff area, while an additional three were between the lower and upper bounds for adequate storage volume. Thus, only six ponds were designed properly.

The most significant pond design variable is the detention time, which is, among other factors, a function of the pond volume. In cognizance of this, both OSM and EPA have linked the storm exemption provisions to design, construction, and maintenance of ponds of a certain volume. As indicated above, this volume had been specified as that required to contain all the runoff from a 10-year, 24-hour storm that drains into the pond. Because of its relative importance in treatment efficiency, the pond volume was explored more thoroughly in this study.

To determine whether or not each pond was sized to the OSM criterion, the data provided by the companies were used in conjunction with precipitation data from the literature to calculate the "OSM pond volume." This value could be compared with the actual pond volume provided by the facility. Table 4-2 summarizes the inputs required to calculate the pond volume.

Table 4-1

SEDIMENTATION POND DESIGN CRITERIA SUPPLIED BY FACILITIES

Facility ID	State	Pond	Design Sediment Storage (acre-ft/acre disturbed)	Occupied Sediment Storage (%)	Design Theoretical Detention Time Hours
OSM Criterion	-	-	0.100*	60	24
15	WV	1	0.125	31.3	1.13
15	WV	2	0.125	27.8	0.90
25	OH	4	0.056[1]	**	**
25	OH	7	0.136	**	**
33	IN	1	**	8.76	46
33	IN	2	0.100	<0.10	64.7
37	IL	6	0.069	Negligible	12
38	KY	19	0.179	**	173 (base flow)
85	IL	1	0.020	**	10
101	OH	2	0.125	None	24
123	IL	3	0.100	**	173 (base flow)
181	KY	99	0.100	20	10
182	MT	1	0.113	Negligible	24
182	MT	2	0.113	Negligible	24
183	VA	1	**	**	**
184	WV	7	0.076	3.82	**
185	WV	4	0.073	5	**
186	PA	2	0.200	**	**
187	PA	1	0.114	**	**
191	AL	18	0.075	10	2.15
191	AL	55	0.352	5	2.74
192	WY	4	0.200	**	24
192	WY	6	0.375	**	24

*Sediment storage volume may be exempted down to 0.035 acre-feet disturbed.

**No information available.

[1] A large pond (#3) is located directly below pond 4.

Table 4-1 (Continued)

SEDIMENTATION POND DESIGN CRITERIA SUPPLIED BY FACILITIES

Facility ID	State	Pond	Embankment Height (feet)	Width of Top of Embankment (feet)		Dewatering Device
OSM Criterion	-	-	H	(H + 35)/5		Any Device
				OSM Required	Actual	Type of Devices
15	WV	1	9.2	9	14	Spillway
15	WV	2	10	9	14	Spillway
25	OH	4	**	**	**	36" perforated stand pipe
25	OH	7	**	**	**	24" perforated stand pipe
33	IN	1	**	**	**	Open channel*
33	IN	2	**	**	**	Open channel*
37	IL	6	**	**	**	Open channel*
38	KY	19	**	**	**	Earth cut channel*
85	IL	1	**	**	**	60" corrugated pipe
101	OH	2	**	**	**	Horizontal 18" pipe
123	IL	3	**	**	**	**
181	KY	99	10	9	15	Combination Riser*
182	MT	1	8 1/2	8.65	15	Decant spillway*
182	MT	2	16	10.2	15	Decant spillway*
183	VA	1	**	**	**	Riser pipe**
184	WV	7	**	**	**	Channel
185	WV	4	10	9	14	Spillway
186	PA	2	14	9.8	10	Perforated riser only
187	PA	1	>19	**	20	Riser with syphon only
191	AL	18	**	**	**	18" pipe
191	AL	55	**	**	**	5 ft. pipe
192	WY	4	**	**	**	Earthen spillway*
192	WY	6	**	**	**	Earthen spillway*

**No information available

Table 4-2

SUMMARY OF INPUTS REQUIRED TO CALCULATE OSM POND VOLUME

Facility Code	State	Pond Number	10-Year, 24-Hour Precipitation Event (Total Inches)*	Boil Type**	Drainage Area (Acres)			Slope of Area	Composite Runoff Curve Numbers	Pond Area (Acres)	Calculated Pond to Meet "OSM" D (Acre-Feet)
					Actively Mined	Disturbed Area	Virgin Area				
15	WV	1	3.5 - 4.0	B–C	NS†	18.5	488.0	47	65.9	0.44	35.6 - 48.3
15	WV	2	3.5 - 4.0	B–C	NS	10.0	195.8	57	67.0	0.43	15.0 - 19.7
25	OH	3	3.5 - 4.0				No additional data submitted				
25	OH	4	3.5 - 4.0	B–C1† D†*	NS	36	99.5	28	80.6	0.33	19.1 - 23.7
25	OH	7	3.5 - 4.0	B–C†† D†*	27.5	27.5	33.8	28	85.4	0.25	10.6 - 12.8
33	IN	1	4.0 - 5.0	C	NS	90.7	43.5	3	88.0	2.17	30.6 - 41.1
33	IN	2	4.0 - 5.0	C	NS	27.1	18.8	4	81.0	3.22	8.1 - 11.4
37	IL	6	4.0 - 5.0	C	NS	280.0	1120.0	3	81.1	2.79	248.8 - 349.5
38	KY	19	4.0 - 5.0	B	NS	67	223.2	2	63.2	1.91	22.6 - 36.9
85	IL	1	4.0 - 5.0	B–C	NS	110	0	15	76.7	1.80	16.5 - 23.8
101	OH	2	3.5 - 4.0	A–B	NS	190	115	7	67.4	5.03	22.7 - 28.6
123	IL	3	4.0 - 5.0	C	NS	820.4	3737.6	0.7	77.7	33	710.2 - 1020.8
181	KY	99	4.0 - 5.0	C	NS	38.9	0	84	80.5	2.00	6.8 - 9.5
182	MT	1	2.5 - 3.0	B	NS	70.5	0	25	73.3	1.80	3.4 - 5.2
182	MT	1	2.5 - 3.0	B	NS	46.2	0	5	63.3	1.34	2.2 - 3.4

*Data from "A Compliance Manual—Methods for Meeting OSM Requirements," Skelly and Loy Engineers, McGraw-Hill, Inc. New York, New York, 1979, p. 6-34.

**See text for explanation of soil types.

†NS - Not supplied by the facility.

††Disturbed.

†*Virgin.

Table 4-2 - Continued

SUMMARY OF INPUTS REQUIRED TO CALCULATE OSM POND VOLUME

Facility Code	State	Pond Number	10-Year, 24-Hour Precipitation Event (Total Inches)*	Soil Type**	Drainage Area (Acres) Actively Mined	Drainage Area (Acres) Disturbed Area	Drainage Area (Acres) Virgin Area	Slope of Area	Composite Runoff Curve Numbers	Pond Area (Acres)	Calculated Pond to Meet "OSM" D (Acre-Feet)
183	WV	1	3.5 - 4.0	C	0	31	76	39	75.1	0.74	11.8 - 15.0
184	WV	7	3.5 - 4.0	C††	0	15	60	50	64.0	0.15	4.6 - 6.1
				B†*							
185	WV	4	3.5 - 4.0	C	NS	53.8	50	50	75.0	0.84	20.8 - 26.4
186	PA	2	3.5 - 4.0	C-D	NS	12	0	150	75.2	0.50	1.3 - 1.7
187	PA	1	3.5 - 4.0	C	NS	70	26	14	77.9	3.10	12.1 - 15.1
191	AL	55	6.0 - 7.0	B-C	NS	350	130	14	74.0	8.30	127.4 - 161.8
191	AL	18	6.0 - 7.0	B-C	NS	61.5	3.5	4	76.1	0.94	18.4 - 23.1
192	WY	4	2.5 - 3.0	C	NS	41	41	3	80.0	2.22	6.1 - 8.5
192	WY	6	2.5 - 3.0	D	NS	12	33	2	86.3	6.86	4.8 - 6.3

*Data from "A Compliance Manual—Methods for Meeting OSM Requirements," Skelly and Loy Engineers, McGraw-Hill, Inc., New York, New York, 1979, p. 6-34.

**See text for explanation of soil types.

††Disturbed.

†*Virgin.

Many methods are available to arrive at the "necessary" pond volume, but only the method used is detailed below. An alternate method is presented in Appendix B.

The selected method uses a Soil Conservation Service (SCS) runoff curve number. The runoff curve number is based on establishing a relationship between rainfall and runoff volumes. This depends upon the soil and land cover types.

Four hydrologic soil groups are identified which define the potential infiltration and water transmission rates:

A (Low Runoff Potential). High infiltration rate and water transmission rate. Example: sands, gravel.

B Moderate infiltration rate and water transmission rate. Example: sandy loam.

C Slow infiltration rate and water transmission rate. Example: clay and silty loam.

D (High Runoff Potential). Very slow infiltration rate and water transmission rate. Example: tight clay or clay pan (soil with permanent high water table).

Using the land cover type supplied by industry and soil type, Table 4-3 can be used to determine the runoff curve number for each type of drainage area. A composite runoff curve number for an entire drainage area can be determined by calculating a weighted average of the runoff curve numbers from the individual drainage areas. Using this composite curve number and the amount of rainfall associated with a given storm event, runoff depth for the drainage area is obtained (in inches of water) as shown on Table 4-4. The runoff volume is then calculated as follows:

$$V = A \times R/12$$

Table 4-3

SCS RUNOFF CURVE NUMBERS

Land Cover	Condition	Soil Group A	B	C	D
Virgin Lands					
Forests	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	25	55	70	77
Farmsteads	--	59	74	82	86
Meadow	Good	30	58	71	78
Pasture/Range	Fair	49	69	79	84
Regraded - Revegetated					
Close Seeded Legumes (Contoured & Terraced)	Poor	63	73	80	83
	Good	51	67	76	80
Small Grains (Contoured & Terraced)	Poor	61	72	79	82
	Good	59	70	78	81
Row Crops (Contoured & Terraced)	Poor	66	74	80	82
	Good	62	71	78	81
Fallow	--	77	86	91	94
Cleared Unvegetated					
Dirt Roads	--	72	82	87	89
Hard Surface Roads (or Pit)	--	74	84	90	92
Paved Surfaces	--	98	98	98	98

Source: Skelly and Loy Engineers, A Compliance Manual--Methods for Meeting OSM Requirements, McGraw-Hill, Inc., New York, New York, 1979, p. 6-32.

Table 4-4

RUNOFF DEPTH IN INCHES FOR SELECTED CURVE NUMBERS AND RAINFALL AMOUNTS

Rainfall (Inches)	Runoff Curve Number								
	60	65	70	75	80	85	90	95	98
1.0	0	0	0	0.03	0.08	0.17	0.32	0.56	0.79
1.2	0	0	0.03	0.07	0.15	0.28	0.46	0.74	0.99
1.4	0	0.02	0.06	0.13	0.24	0.39	0.61	0.92	1.18
1.6	0.01	0.05	0.11	0.20	0.34	0.52	0.76	1.11	1.38
1.8	0.03	0.09	0.17	0.29	0.44	0.65	0.93	1.29	1.58
2.0	0.06	0.14	0.24	0.38	0.56	0.80	1.09	1.48	1.77
2.5	0.17	0.30	0.46	0.65	0.89	1.18	1.53	1.96	2.27
3.0	0.33	0.51	0.72	0.96	1.25	1.59	1.98	2.45	2.78
4.0	0.76	1.03	1.33	1.67	2.04	2.46	2.92	3.43	3.77
5.0	1.30	1.65	2.04	2.45	2.89	3.37	3.88	4.42	4.76
6.0	1.92	2.35	2.80	3.28	3.78	4.31	4.85	5.41	5.76
7.0	2.60	3.10	3.62	4.15	4.69	5.26	5.82	6.41	6.76
8.0	3.33	3.90	4.47	5.04	5.62	6.22	6.81	7.40	7.76
9.0	4.10	4.72	5.34	5.95	6.57	7.19	7.79	8.40	8.76
10.0	4.90	5.57	6.23	6.88	7.52	8.16	8.78	9.40	9.76
11.0	5.72	6.44	7.13	7.82	8.48	9.14	9.77	10.39	10.76
12.0	6.56	7.32	8.05	8.76	9.45	10.12	10.76	11.39	11.76

NOTE: To obtain runoff depths for other curve numbers and rainfall amounts not shown in this table, use an arithmetic interpolation.

Source: Skelly and Loy Engineers, A Compliance Manual--Methods for Meeting OSM Requirements, McGraw-Hill, Inc., New York, New York, 1979, p. 6-32.

where:
- V is volume, in acre-feet.
- A is the total area drained to the pond, in acres.
- R is the runoff depth, in inches of water.

A sample calculation of this method is found in Appendix B.

Table 4-5 presents the results for all ponds and indicates which facilities meet the OSM pond volume criterion and which do not. Those marked "Yes/No" fall between the upper and lower boundaries of the necessary volume, indicating that the pond may or may not be adequately sized according to the OSM standard.

4.2 Wastewater Characterization

During the course of this program, two basic periods were characterized: (1) baseflow or "dry" conditions (no rain), and (2) rainfall or "wet" conditions (day of rainfall or day after rainfall). The wastewater characteristics from the dry period represent the data base for reclamation areas, while the results from samples taken during wet conditions were used to augment available data on effluent qualities during various storm events.

4.2.1 Toxic and Nonconventional Metals

Summaries of toxic and nonconventional metals analyzed for during the program are presented in Tables 4-6 through 4-11. These tables present data for influent and effluent during wet or rain conditions and during dry or baseflow conditions. It should be noted, as shown on Tables 4-10 and 4-11, that the rainfall

Table 4-5

COMPARISON OF OSM "REQUIRED" VOLUMES AND ACTUAL POND VOLUMES

Facility	State	Pond	OSM "Required" Volume Acre-Feet	Actual Pond Volume Acre-Feet	Does the Pond Comply With OSM Criterion?
15	WV	1	35.6 - 48.3	2.6	No
15	WV	2	15.0 - 19.7	1.6	No
25	OH	4	19.1 - 23.7	1.3	No
25	OH	7	10.6 - 12.8	1.5	No
33	IN	1	30.6 - 41.1	48.5	Yes
33	IN	2	8.1 - 11.4	19.4	Yes
37	IL	6	248.8 - 349.5	32.2	No
38	KY	19	22.6 - 36.9	28.6	Yes/No
85	IL	1	16.5 - 23.8	16.2	No
101	OH	2	22.7 - 28.6	28.2	Yes/No
123	IL	3	710.2 - 1020.8	215	No
181	KY	99	6.7 - 9.5	3.9	No
182	MT	1	3.4 - 5.2	13.5	No
182	MT	2	2.2 - 3.4	10.0	No
183	WV	1	11.8 - 15.0	3.1	No
184	WV	7	4.6 - 6.1	1.9	No
185	WV	4	20.8 - 26.4	6.6	No
186	PA	2	1.3 - 1.7	3.3	Yes
187	PA	1	12.0 - 15.1	20	Yes

Table 4-5 (Continued)

COMPARISON OF OSM "REQUIRED" VOLUMES AND ACTUAL POND VOLUMES

Facility	State	Pond	OSM "Required" Volume Acre-Feet	Actual Pond Volume Acre-Feet	Does the Pond Comply With OSM Criterion?
191	AL	18	18.4 - 23.1	20	Yes/No
191	AL	55	127.4 - 161.8	125	No
192	WY	4	6.1 - 8.5	13.6	Yes
192	WY	6	4.8 - 6.3	16.8	Yes

Table 4-6

METALS RESULTS FOR RAW WASTEWATER DURING DRY CONDITIONS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	CONCENTRATIONS IN UG/L			
			MEAN	MEDIAN	90%	MAX
ANTIMONY (TOTAL)	83	17	57	50	100	250
ARSENIC (TOTAL)	83	3	26	20	40	45
BERYLLIUM (TOTAL)	83	6	0.6	0.5	0.5	6.3
CADMIUM (TOTAL)	83	3	2.7	2.5	2.5	16.0
CHROMIUM (TOTAL)	82	14	6	3	7	115
COPPER (TOTAL)	83	20	5	3	14	20
LEAD (TOTAL)	83	4	17	15	15	103
MERCURY (TOTAL)	83	1	20.2	20.0	20.0	40.0
NICKEL (TOTAL)	83	6	31	25	45	110
SELENIUM (TOTAL)	83	3	26	25	25	96
SILVER (TOTAL)	83	3	2.6	2.5	2.6	6.2
THALLIUM (TOTAL)	83	0	-	-	-	<100.0
ZINC (TOTAL)	83	69	65	16	85	1050
MANGANESE (TOTAL)	83	82	430	204	1036	3690
IRON (TOTAL)	83	80	1857	310	4010	47300

Table 4-7

METALS RESULTS FOR POND EFFLUENT DURING DRY CONDITIONS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	CONCENTRATIONS IN UG/L			
			MEAN	MEDIAN	90%	MAX
ANTIMONY (TOTAL)	79	17	61	50	112	467
ARSENIC (TOTAL)	79	0	-	-	-	< 80.0
BERYLLIUM (TOTAL)	79	5	0.6	0.5	0.5	3.2
CADMIUM (TOTAL)	79	3	2.7	2.5	2.5	9.8
CHROMIUM (TOTAL)	79	14	5	3	11	37
COPPER (TOTAL)	79	19	6	3	13	50
LEAD (TOTAL)	79	0	-	-	-	< 30.0
MERCURY (TOTAL)	79	0	-	-	-	< 40.0
NICKEL (TOTAL)	79	3	32	25	45	97
SELENIUM (TOTAL)	79	2	25	25	25	87
SILVER (TOTAL)	79	3	2.6	2.5	2.5	7.1
THALLIUM (TOTAL)	79	0	-	-	-	<100.0
ZINC (TOTAL)	79	61	29	13	78	143
MANGANESE (TOTAL)	79	79	396	232	900	2040
IRON (TOTAL)	79	77	854	228	2200	16400

Table 4-8

METALS RESULTS FOR RAW WASTEWATER DURING WET CONDITIONS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	CONCENTRATIONS IN UG/L			
			MEAN	MEDIAN	90%	MAX
ANTIMONY (TOTAL)	73	21	66	50	133	235
ARSENIC (TOTAL)	73	8	50	20	82	890
BERYLLIUM (TOTAL)	73	16	1.7	0.5	5.7	20.0
CADMIUM (TOTAL)	73	15	6.0	2.5	14.6	106.0
CHROMIUM (TOTAL)	73	36	25	3	70	525
COPPER (TOTAL)	73	36	34	3	107	791
LEAD (TOTAL)	73	5	17	15	18	92
MERCURY (TOTAL)	73	0	-	-	-	< 40.0
NICKEL (TOTAL)	73	14	62	25	140	1170
SELENIUM (TOTAL)	73	3	26	25	25	70
SILVER (TOTAL)	73	4	2.7	2.5	2.8	6.5
THALLIUM (TOTAL)	73	0	-	-	-	<100.0
ZINC (TOTAL)	73	67	537	35	351	19060
MANGANESE (TOTAL)	73	73	1474	662	2792	21900
IRON (TOTAL)	73	72	27894	3210	89020	720000

Table 4-9

METALS RESULTS FOR POND EFFLUENT DURING WET CONDITIONS

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	CONCENTRATIONS IN UG/L			
			MEAN	MEDIAN	90%	MAX
ANTIMONY (TOTAL)	71	13	50	50	97	270
ARSENIC (TOTAL)	71	0	-	-	-	< 80.0
BERYLLIUM (TOTAL)	71	4	0.5	0.5	0.5	1.4
CADMIUM (TOTAL)	71	1	2.6	2.5	2.5	7.6
CHROMIUM (TOTAL)	71	11	5	3	17	27
COPPER (TOTAL)	71	19	7	3	25	64
LEAD (TOTAL)	71	0	-	-	-	< 30.0
MERCURY (TOTAL)	71	0	-	-	-	< 40.0
NICKEL (TOTAL)	71	0	-	-	-	< 90.0
SELENIUM (TOTAL)	71	1	25	25	25	42
SILVER (TOTAL)	71	5	2.7	2.5	2.5	7.2
THALLIUM (TOTAL)	71	0	-	-	-	<100.0
ZINC (TOTAL)	71	60	23	16	54	134
MANGANESE (TOTAL)	71	70	442	285	984	2110
IRON (TOTAL)	71	71	1794	1000	4972	11900

Table 4-10

METALS RESULTS FOR RAW WASTEWATER WITH RAINFALL CONDITION UNIDENTIFIED

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	CONCENTRATIONS IN UG/L			
			MEAN	MEDIAN	90%	MAX
ANTIMONY (TOTAL)	63	21	84	50	241	369
ARSENIC (TOTAL)	63	21	64	20	146	491
BERYLLIUM (TOTAL)	63	25	3.2	0.5	9.9	15.0
CADMIUM (TOTAL)	63	23	10.0	2.5	22.6	82.0
CHROMIUM (TOTAL)	63	14	12	3	10	175
COPPER (TOTAL)	63	26	91	3	120	233
LEAD (TOTAL)	63	0	-	-	-	< 30.0
MERCURY (TOTAL)	63	0	-	-	-	< 40.0
NICKEL (TOTAL)	63	34	391	51	1410	1660
SELENIUM (TOTAL)	63	0	-	-	-	< 80.0
SILVER (TOTAL)	63	0	-	-	-	< 5.0
THALLIUM (TOTAL)	63	9	64.3	50.0	127.2	199.0
ZINC (TOTAL)	63	58	793	80	2000	3400
MANGANESE (TOTAL)	63	63	7526	1660	26900	34230
IRON (TOTAL)	63	63	32067	1500	91940	270000

Table 4-11

METALS RESULTS FOR POND EFFLUENT WITH RAINFALL CONDITION UNIDENTIFIED

COMPOUND	TOTAL NUMBER SAMPLES	NUMBER TOTAL DETECTS	CONCENTRATIONS IN UG/L			
			MEAN	MEDIAN	90%	MAX
ANTIMONY (TOTAL)	66	14	50	50	123	261
ARSENIC (TOTAL)	66	0	26	20	43	151
BERYLLIUM (TOTAL)	66	21	1.1	0.5	2.0	5.0
CADMIUM (TOTAL)	66	10	3.5	2.5	7.6	14.0
CHROMIUM (TOTAL)	66	6	4	3	3	36
COPPER (TOTAL)	66	24	10	3	29	47
LEAD (TOTAL)	66	0	-	-	-	< 30.0
MERCURY (TOTAL)	66	0	-	-	-	< 40.0
NICKEL (TOTAL)	66	44	116	64	311	410
SELENIUM (TOTAL)	66	0	-	-	-	< 50.0
SILVER (TOTAL)	66	0	-	-	-	< 5.0
THALLIUM (TOTAL)	66	2	52.2	50.0	50.0	137.0
ZINC (TOTAL)	66	64	257	85	817	924
MANGANESE (TOTAL)	66	66	4534	2545	12100	14560
IRON (TOTAL)	66	66	4242	823	12260	40500

condition was not recorded or specified for roughly one third of the analytical results. This stemmed primarily from incomplete documentation of samples by industry personnel.

Examining the mean values for untreated wastewater listed on Table 4-6, it can be readily seen that the toxic metals all averaged well below 0.1 mg/l. In fact, the 90th percentile was, in each case, less than or equal to 0.1 mg/l. As expected, iron and manganese are somewhat higher, but still substantially lower than the BPT limitations. The maximum values for all the metals indicate some variation from site to site.

The sedimentation ponds provide reduction of the metallic species, as shown on Table 4-7. Four of the toxic metals were never detected, and an additional five appeared in less than 10 percent of the samples taken, and then at very low values. Copper and chromium were detected in a significant number of samples, but always below 0.05 mg/l. Antimony was detected in 17 of 79 samples taken (22 percent), and at values higher than would be expected from the type of areas being investigated. To determine if this unexpected result stemmed from the analytical procedure, the concentrates were reanalyzed by a different protocol. Results indicate that when atomic absorption was used in place of inductively coupled argon plasma emission spectroscopy, antimony was not detected above 0.1 mg/l. Zinc appears frequently in effluent samples from the majority of facilities, however, the median concentration is very low at .013 mg/l, indicating that the high values occurred infrequently. Indeed, further research showed that zinc occurred above 0.1 mg/l only in a few isolated cases. This is to be expected given the natural variation and common occurrence of zinc compounds in all soils.

The results for the untreated wastewater during wet or storm conditions (Table 4-8) and where the rainfall status was not recorded (Table 4-10) show elevated levels, which corresponds to the increased flow of sediment to the pond. The effluent values (Tables 4-9 and 4-11), however, are quite similar to the effluent values for dry conditions, with one exception. Nickel appears in a large number of effluent samples in Table 4-11. The vast majority of the detected values for nickel, however, occurred at one facility. Again, this is not unusual given the specific soil characteristics at that facility and other factors unique to each site.

As a result of the infrequent occurrence of the toxic metals and the low concentrations encountered when detections did occur, sampling and analysis for the toxic metals and manganese beyond the first six months of the program were deemed unnecessary and thus terminated.

4.2.2 Settleable Solids

Data summaries for settleable solids are found by facility and pond in Tables 4-12 through 4-15. These data are presented by facility and pond to illustrate variation in influent characteristics and to examine any variation in performance from pond to pond. Settleable solids were detected in 47 percent of influent samples during dry conditions and in approximately 70 percent of the influent samples during wet conditions. Detected values occurred in 39 percent and 59 percent of the effluent samples for dry and wet conditions, respectively.

Examining the mean values for influent waters during dry conditions, it can be seen that only five of the 22 ponds had concentrations of settleable solids above 1.0 ml/l. For wet conditions, eleven of the 20 ponds have mean influent values above 1.0 ml/l. This indicates that, for the remaining facilities, reductions were difficult to quantify. The mean effluent values

Table 4-12

SETTLEABLE SOLIDS DATA BY FACILITY AND POND
RAW WASTEWATER
DRY CONDITIONS

Facility	Pond	Number of Samples	Number of Detects	Concentrations (ml/l)				
				Minimum	Mean	Median	90%	Maximum
15	1	24	3	<0.1	0.06	<0.1	0.10	0.10
15	2	18	3	<0.1	0.06	<0.1	0.10	0.15
25	3	3	2	<0.1	0.95	0.4	2.40	2.40
25	4	19	2	<0.1	0.06	<0.1	0.10	0.10
25	7	21	7	<0.1	2.05	<0.1	6.16	33.10
33	1	25	25	0.00	0.01	0.00	0.00	0.10
33	2	20	20	0.00	0.02	0.00	0.09	0.30
37	6	28	7	<0.1	0.65	<0.1	0.54	9.02
38	19	10	8	<0.1	3.32	0.29	19.45	21.00
85	1	20	16	0.00	0.10	0.02	0.48	0.50
101	2	20	20	0.00	2.33	0.25	10.46	21.00
123	3	9	1	<0.1	4.38	<0.1	39.00	39.00
181	99	8	5	<0.1	0.18	0.10	0.80	0.80
183	1	27	0	--	--	--	--	<0.1
184	7	24	1	<0.1	<0.1	<0.1	<0.1	0.10
185	4	20	0	--	--	--	--	<0.1
186	2	32	20	0.00	0.02	0.00	<0.1	<0.1
187	1	33	25	0.00	0.01	0.00	<0.1	<0.1
191	18	2	2	0.5	0.22	0.22	0.40	0.4
191	55	2	2	0.0	0.01	0.01	0.02	0.02
192	4	4	3	<0.1	1.16	1.05	2.50	2.50
192	6	3	3	0.1	0.50	0.40	1.00	1.00
Overall		372	175	0.0	0.55	NC	NC	39.0

NC - Not calculated.

Table 4-13

SETTLEABLE SOLIDS DATA BY FACILITY AND POND
EFFLUENT
DRY CONDITIONS

Facility	Pond	Number of Samples	Number of Detects	Concentrations (ml/l)				
				Minimum	Mean	Median	90%	Maximum
15	1	25	2	< .1	0.06	< .1	0.07	0.20
15	2	18	4	< .1	0.09	< .1	0.22	0.40
25	3	3	0	--	--	--	--	< .1
25	4	18	6	< .02	0.08	< .1	0.20	0.20
25	7	22	3	< .1	0.06	< .1	0.10	0.20
33	1	26	26	0.00	0.00	0.00	0.00	0.00
33	2	22	22	0.00	0.00	0.00	0.00	0.00
37	6	28	8	< .1	0.31	0.40	<1.0	<1.0
38	19	10	0	--	--	--	--	< .1
85	1	20	15	0.00	0.02	0.00	0.05	0.20
101	2	7	7	0.00	0.08	0.05	0.30	0.30
123	3	9	0	--	--	--	--	< .1
181	99	18	0	--	--	--	--	< .1
183	1	26	0	--	--	--	--	< .1
184	7	25	1	< .1	0.06	< .1	< .1	0.20
185	4	20	1	< .1	0.05	< .1	< .1	0.10
186	2	33	20	0.00	0.02	0.00	< .1	< .1
187	1	33	25	0.00	0.01	0.00	< .1	< .1
191	18	3	3	0.0	0.0	0.0	0.0	0.0
191	55	1	1	0.0	0.0	0.0	0.0	0.0
Overall		367	144	0.0	0.06	NC	NC	0.4

NC - Not calculated.

Table 4-14

SETTLEABLE SOLIDS DATA BY FACILITY AND POND
RAW WASTEWATER
WET CONDITIONS

Facility	Pond	Number of Samples	Number of Detects	Concentrations (ml/l)				
				Minimum	Mean	Median	90%	Maximum
15	1	13	2	<0.1	0.42	<0.1	2.7	3.5
15	2	13	1	<0.1	0.08	<0.1	0.26	0.4
25	3	2	1	<0.1	6.15	6.15	12.2	12.2
25	4	12	11	0.15	0.57	0.2	2.3	2.3
25	7	15	10	0.0	1.68	0.15	9.1	14.4
33	1	62	62	0.0	0.02	0.0	0.01	0.6
33	2	61	61	0.0	0.01	0.0	0	0.2
37	6	17	9	<0.1	1.68	0.5	5.4	16.6
38	19	5	4	<0.1	1.07	1.3	2.2	2.2
85	1	30	27	0.0	2.30	0.2	2.4	38.0
101	2	39	39	0.02	23.6	0.7	52	370.0
123	3	6	4	<0.1	14.9	4.9	52	52.0
181	99	34	14	<0.1	2.3	<0.1	0.4	72.5
183	1	24	4	<0.1	0.71	<0.1	1.2	13.5
184	7	30	9	<0.1	0.14	<0.1	0.2	1.4
185	4	24	8	<0.1	0.58	<0.1	2.5	3.0
186	2	12	8	0.0	0.10	0.00	0.7	1.0
187	1	12	10	0.0	3.83	0.00	27.0	34.0
191	18	11	11	0.01	1.58	0.34	5.8	6.0
191	55	12	12	0.01	2.85	0.25	22.0	31.0
Overall		436	307	0.0	3.2	NC	NC	370.0

NC - Not calculated.

Table 4-15

SETTLEABLE SOLIDS DATA BY FACILITY AND POND EFFLUENT WET CONDITIONS

Facility	Pond	Number of Samples	Number of Detects	Concentrations (ml/l)				
				Minimum	Mean	Median	90%	Maximum
15	1	13	3	<0.1	0.18	<0.1	0.92	1.0
15	2	12	6	<0.1	0.13	0.1	0.37	0.4
25	3	3	1	0.0	0.02	0.03	<0.1	<0.1
25	4	12	3	<0.1	0.12	0.06	0.35	0.4
25	7	14	5	<0.1	0.09	<0.1	0.24	0.3
33	1	64	64	0.0	0.00	0.0	0.0	0.0
33	2	61	61	0.0	0.00	0.0	0.0	0.0
37	6	17	4	<0.1	0.31	<1.0	<1.0	<1.0
38	19	5	0	--	--	--	--	<0.1
85	1	30	22	0.0	0.07	<0.1	0.2	0.5
101	2	26	26	0.0	0.50	0.3	0.8	6.0
123	3	6	0	--	--	--	--	<0.01
181	99	32	2	<0.1	0.06	<0.1	0.07	0.23
183	1	16	2	<0.1	0.14	<0.1	0.65	1.0
184	7	39	4	<0.1	0.07	<0.1	0.12	0.3
185	4	24	2	<0.1	0.13	<0.1	0.53	1.0
186	2	12	8	0.0	0.02	0.0	<0.1	<0.1
187	1	12	10	0.0	0.01	0.0	<0.1	<0.1
191	18	11	11	0.0	0.13	0.01	0.6	0.6
191	55	11	11	0.0	0.31	0.0	2.4	2.9
Overall		413	245	0.0	0.10	NC	NC	6.0

NC - Not calculated.

in all cases, regardless of the rainfall condition, were less than 0.5 ml/l. Moreover, the overall effluent mean for all ponds in both cases was equal to or less than 0.1 ml/l.

Histograms (frequency distributions) were prepared to illustrate the distribution of the data. Figure 4-1 presents a histogram for "not detected" values for effluents during dry conditions. These "not detected" values actually represent the differing detection limits reported by each company. The vertical axis represents the midpoint value of the range examined for the frequency calculation. For instance, on Figure 4-1, the horizontal row of asterisks at 0.1 ml/l indicate that a certain number of values (in this case, 207) were found in the data base at a range of concentrations between 0.05 ml/l and 0.15 ml/l. A similar plot for "not detected" values during wet conditions appears in Figure 4-2. No apparent difference was found between wet and dry conditions. These plots clearly demonstrate that the detection limit recorded by most companies is 0.1 ml/l; however, this number did fluctuate in a small number of cases. The significant number of values at 1.0 ml/l were recorded by a facility that also recorded a detection limit of 0.1 ml/l for a substantial number of samples. To summarize, the detection limit was recorded as 0.1 ml/l or less, approximately 94 percent of the time "not detected" values were reported for effluent samples.

Histograms for detected values in pond effluents are depicted in Figures 4-3 (dry) and 4-4 (wet). Over 71 percent of the values were reported as 0.0 ml/l. For dry conditions, 100 percent of the values were less than or equal to 0.4 ml/l. During wet conditions, 95 percent were less than or equal to 0.5 ml/l. Thirteen values above 0.5 ml/l were recorded by six of the 22 sites (13 samples in a total of 789 effluent samples). In fact, four of the 13 highest values were reported by facility 101 in eastern Ohio. In addition to 115 acres of virgin and

```
MIDPOINT
 VALUE                                            FREQ  CUM.  PERCENT     CUM.
                                                        FREQ           PERCENT
        ≠
  0.01  ≠                                            1     1     0.45     0.45
        ≠
  0.10  ≠***************************************** 207   208    92.83    93.27
        ≠
  0.20  ≠                                            0   208     0.00    93.27
        ≠
  0.30  ≠                                            0   208     0.00    93.27
        ≠
  0.40  ≠                                            1   209     0.45    93.72
        ≠
  0.50  ≠                                            0   209     0.00    93.72
        ≠
  0.60  ≠                                            0   209     0.00    93.72
        ≠
  0.70  ≠                                            0   209     0.00    93.72
        ≠
  0.80  ≠                                            0   209     0.00    93.72
        ≠
  0.90  ≠                                            0   209     0.00    93.72
        ≠
  1.00  ≠***                                        14   223     6.28   100.00
        ≠
        ----+---+---+---+---+---+---+---+---+---+-
           20  40  60  80 100 120 140 160 180 200

                       FREQUENCY
```

Figure 4-1

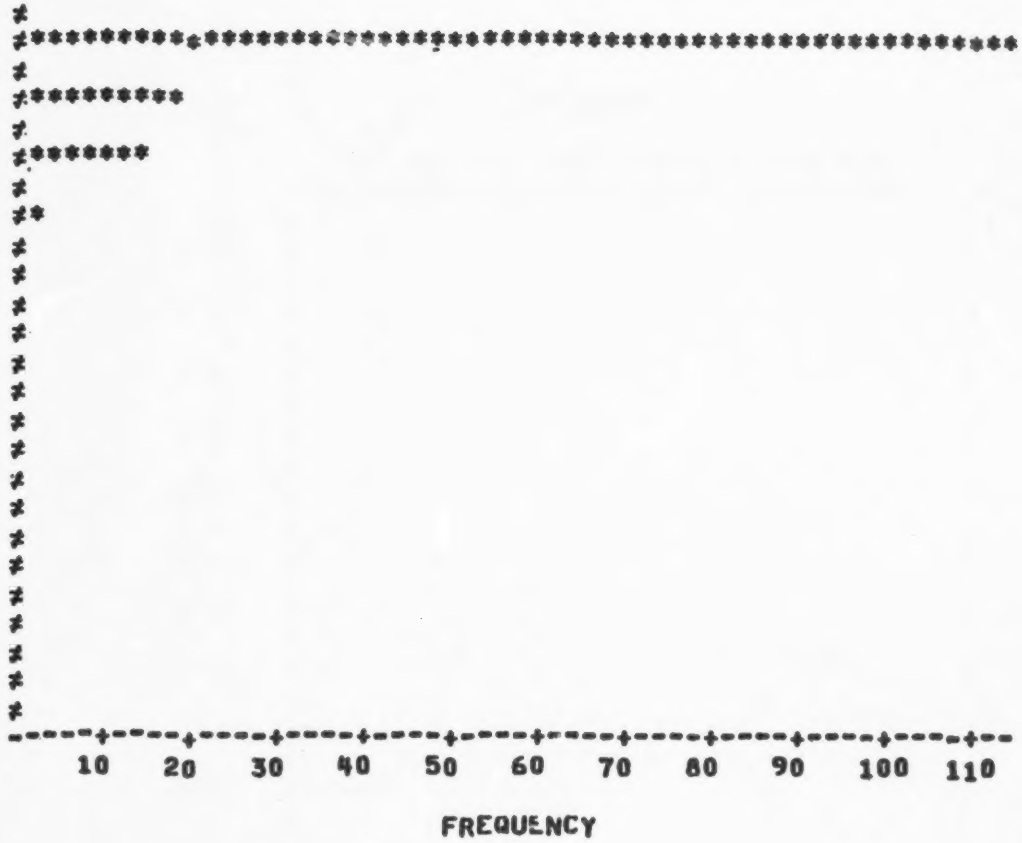
HISTOGRAM OF "NOT-DETECTED" EFFLUENT SETTLEABLE SOLIDS
VALUES DURING DRY CONDITIONS

```
MIDPOINT
 VALUE                                                                       FREQ  CUM.  PERCENT   CUM.
                                                                                   FREQ           PERCEN
       *
 0.01  *                                                                        1     1     0.59     0.5
       *
 0.10  ****************************************************************       159   160    93.53    94.1
       ****************************************************************
 0.20  *                                                                        1   161     0.59    94.7
       *
 0.30  *                                                                        0   161     0.00    94.7
       *
 0.40  *                                                                        0   161     0.00    94.7
       *
 0.50  *                                                                        0   161     0.00    94.7
       *
 0.60  *                                                                        0   161     0.00    94.7
       *
 0.70  *                                                                        0   161     0.00    94.7
       *
 0.80  *                                                                        0   161     0.00    94.7
       *
 0.90  *                                                                        0   161     0.00    94.7
       *
 1.00  *****                                                                    9   170     5.29   100.0
       *
       ----+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
          10  20  30  40  50  60  70  80  90 100 110 120 130 140 150 160

                              FREQUENCY
```

Figure 4-2

HISTOGRAM OF "NOT-DETECTED" EFFLUENT SETTLEABLE SOLIDS VALUES DURING WET CONDITIONS



MIDPOINT VALUE	FREQ	CUM. FREQ	PERCENT	CUM. PERCENT
0.0	113	113	78.47	78.47
0.1	17	130	11.81	90.28
0.2	13	143	9.03	99.31
0.4	1	144	0.69	100.00
0.6	0	144	0.00	100.00
0.8	0	144	0.00	100.00
1.0	0	144	0.00	100.00
2.0	0	144	0.00	100.00
3.0	0	144	0.00	100.00
4.0	0	144	0.00	100.00
5.0	0	144	0.00	100.00
6.0	0	144	0.00	100.00

Figure 4-3

HISTOGRAM OF DETECTED EFFLUENT SETTLEABLE SOLIDS VALUES FOR DRY CONDITIONS

```
MIUPOINT
VALUE
                                                            FREQ  CUM.   PERCENT    CUM.
      ≠                                                           FREQ              PERCENT
0.0   ≠**********************************                    172   172    68.25     68.25
      ≠
0.1   ≠*******                                                34   206    13.49     81.75
      ≠
0.2   ≠****                                                   22   228     8.73     90.48
      ≠
0.4   ≠*                                                       7   235     2.78     93.25
      ≠
0.6   ≠**                                                      9   244     3.57     96.83
      ≠
0.8   ≠                                                        1   245     0.40     97.22
      ≠
1.0   ≠*                                                       5   250     1.98     99.21
      ≠
2.0   ≠                                                        0   250     0.00     99.21
      ≠
3.0   ≠                                                        1   251     0.40     99.60
      ≠
4.0   ≠                                                        0   251     0.00     99.60
      ≠
5.0   ≠                                                        0   251     0.00     99.60
      ≠
6.0   ≠                                                        1   252     0.40    100.00
      ≠
      ----+---+---+---+---+---+---+---+--
         20  40  60  80 100 120 140 160

                 FREQUENCY
```

Figure 4-4

HISTOGRAM OF DETECTED EFFLUENT SETTLEABLE SOLIDS
VALUES DURING WET CONDITIONS

reclaimed areas, this sedimentation pond serves 190 acres of disturbed area. From pond design data and a topographic map submitted by the company, these 190 acres appear to be largely unreclaimed spoil areas. This differs markedly from other ponds in the study. Runoff from the spoil areas will be heavily loaded with sediment and evidently enters the pond at diffuse locations as well as the specified inflow point. This situation causes only a small portion of the pond to be used and thus may result in a substantial reduction in sediment removal efficiency, especially during intense rainfall events. If this spoil area was properly reclaimed, erosion would be substantially reduced and the achievable effluent quality would improve. Also at this facility, a second inflow point located less than 200 feet from the outflow further exacerbates the problem. This situation exists even though the pond has a surface area of over five acres and measures almost 1,000 feet in available length. Having an inflow point so close to the outflow fails to utilize the full sediment removal capacity of the pond, which again has a deleterious effect on effluent quality. Therefore, though this pond is adequately sized according to storm exemption criteria, it does not represent an adequate or exemplary design. This discounts the validity of the effluent data from this facility.

A similar situation exists for pond 55 at facility 191. Although not sized according to storm exemption criteria, it also has similar features to pond 2 at facility 101 with respect to multiple points adjacent to a spoil area. Thus, data from this facility is also of doubtful validity.

Two values of 0.6 ml/l were reported during wet conditions from a sedimentation pond in Alabama. The pond is sized between the upper and lower ranges of the OSM design storage volume criterion. Because the pond is not clearly within the "OSM pond" category, these data are not considered to be from an exemplary facility.

The remaining settleable solids values above 0.5 ml/l were reported by facilities 15, 183, and 185. A review of the pond designs at these facilities revealed no particular anomalies except that each was severely undersized with respect to the OSM volume criterion. Of those ponds that were sized to the 10-year, 24-hour criterion and also were properly operated, none were found to discharge settleable solids greater than 0.5 ml/l.

Based on these considerations, 0.5 ml/l represents an achievable daily maximum limitation for areas under reclamation and for ponds subject to the storm events that occurred during the course of this study.

4.2.3 Total Suspended Solids

The capabilities of sedimentation ponds to remove total suspended solids (TSS) have been extensively investigated by several researchers. Few have had access to the amount of data collected during this study; moreover, none have had adequate field data to draw conclusions on sedimentation pond performance during and immediately after rainfall events. This subsection will present and discuss the TSS data reported by the participating facilities.

Tables 4-16 through 4-19 contain summary statistics for each facility and pond. As can be seen, TSS variation is much more substantial than that shown by the settleable solids data. Additionally, great variation in effluent TSS is found from pond to pond, indicating the importance of the type and ground cover of areas draining into the pond, as well as the soil type and terrain. These differences are much greater than those observed for pit pumpage or active area drainage. This is an expected result, given the vast amounts of acreage often associated with the reclamation process and treatment facilities, the length of

Table 4-16

TOTAL SUSPENDED SOLIDS DATA BY FACILITY AND POND
RAW WASTEWATER
DRY CONDITIONS

Facility	Pond	Number of Samples	Concentrations (mg/l) Minimum	Mean	Median	90%	Maximum
15	1	24	0.5	11	6	22	23
15	2	18	0.5	6	4	16	30
25	4	19	6	19	15	36	52
25	7	22	2	90	17	290	4,260
33	1	25	1	13	9	31	64
33	2	26	2	20	14	45	75
37	6	27	50	60	36	188	490
38	19	10	2	102	96	231	243
85	1	20	4	77	40	199	414
101	2	27	15	235	69	818	870
123	3	9	23	213	47	3,060	3,060
181	99	8	1	200	112	738	738
183	1	29	1	6	6	11	13
184	7	24	1	8	4	22	79
185	4	17	1	14	7	35	46
186	2	31	1	33	6	132	282
187	1	33	5	25	19	59	121
191	18	4	37	242	189	341	341
191	55	3	11	188	107	191	191
Overall		369	0.5	48	NC	NC	4,260

NC - Not calculated.

Table 4-17

TOTAL SUSPENDED SOLIDS DATA BY FACILITY AND POND EFFLUENT DRY CONDITIONS

Facility	Pond	Number of Samples	Concentrations (mg/l)				
			Minimum	Mean	Median	90%	Maximum
15	1	30	2	11	9	20	30
15	2	23	0.5	20	15	36	75
25	4	19	5	22	16	39	91
25	7	22	2	20	14	44	109
33	1	26	1	11	8	22	27
33	2	26	1	14	11	27	27
37	6	28	7	41	36	70	90
38	19	10	3	9	10	16	17
85	1	20	4	34	22	50	318
101	2	28	1	29	14	66	128
123	3	9	5	23	15	68	69
181	99	18	1	10	6	28	69
183	1	29	1	10	5	25	93
184	7	25	3	7	6	15	23
185	4	17	3	39	29	81	105
186	2	33	9	94	60	243	464
187	1	33	8	20	17	32	35
191	18	7	4	11	11	18	18
191	55	5	2	5	6	7	7
Overall		408	0.5	25	NC	NC	464

NC - Not calculated.

Table 4-18

TOTAL SUSPENDED SOLIDS DATA BY FACILITY AND POND
RAW WASTEWATER
WET CONDITIONS

Facility	Pond	Number of Samples	Concentrations (mg/l) Minimum	Mean	Median	90%	Maximum
15	1	13	2	86	11	907	1,305
15	2	13	3	17	5	100	101
25	4	12	10	379	100	1,648	1,880
25	7	16	12	771	74	2,889	3,097
33	1	66	2	34	16	95	342
33	2	64	2	29	16	59	229
37	6	17	14	636	131	2,050	3,504
38	19	5	3	315	71	504	504
85	1	30	17	247	71	794	9,148
101	2	42	5	1,949	325	4,578	23,260
123	3	6	33	3,736	528	5,978	5,978
181	99	34	4	233	67	448	10,507
183	1	25	2	114	16	768	2,110
184	7	30	2	36	8	160	453
185	4	21	5	227	21	779	5,460
186	2	12	3	306	55	1,413	1,725
187	1	12	13	7,473	103	22,875	30,090
191	18	17	11	1,075	82	6,447	9,998
191	55	17	4	882	38	6,609	7,053
Overall		452	2	276	NC	NC	30,090

NC - Not calculated.

Table 4-19

TOTAL SUSPENDED SOLIDS DATA BY FACILITY AND POND
EFFLUENT
WET CONDITIONS

Facility	Pond	Number of Samples	Concentrations (mg/l)				
			Minimum	Mean	Median	90%	Maximum
15	1	13	1	63	16	424	504
15	2	12	4	42	29	126	150
25	4	12	16	123	104	256	288
25	7	15	17	74	40	193	214
33	1	65	1	12	10	23	53
33	2	64	1	18	13	34	55
37	6	17	16	59	42	178	294
38	19	5	14	25	23	40	40
85	1	30	1	77	35	134	654
101	2	41	4	162	54	350	966
123	3	6	15	24	23	38	38
181	99	32	4	28	18	63	402
183	1	17	2	103	41	281	321
184	7	30	2	24	14	64	77
185	4	21	10	58	43	147	182
186	2	12	45	202	104	486	504
187	1	12	13	29	30	51	55
191	18	16	2	85	14	887	2,628
191	55	16	1	34	8	341	712
Overall		404	1	52	NC	NC	966

NC - Not calculated.

the revegetation process (five to ten years), and the significant erosion rates associated with the initial stages of the reclamation process. Each of these parameters not only causes reclamation wastewaters to be different from active area drainage, but also leads to wide variation from mine to mine within reclamation areas. Tables 4-16 and 4-18 clearly demonstrate this variation.

Results reported by some of the facilities were surprising. Table 4-20 illustrates this by presenting the efficiencies or percent reductions for each pond for wet and dry conditions. These reductions were calculated based on the lognormal mean influent and effluent values.* Negative reductions indicate that the effluent mean is higher than the influent mean. While this type of variation is possible on specific sample sets (due to retention time of the pond), this behavior in the aggregated data from each facility is subject to question. In some cases, this anomaly can most likely be attributed to errors in the data reporting procedure. In other cases, the problem is probably attributable to sampling procedures. For instance, some ponds possess multiple inflow points. In many instances, only one influent was sampled. However, these multiple influents will contain varying concentrations of TSS. It is easy to envision how an apparent negative efficiency can result. Another mechanism that could cause this is the selection of the sampling location within the influent or effluent stream. The influent stream is more frequently diffuse and shallow. Thus it is more difficult to select a representative location to sample than in

---

*"Lognormal" indicates that the data were distributed approximately lognormally, i.e., a near normal distribution occurred when the logarithm of each point was calculated and plotted. The lognormal mean is calculated from a lognormal model of the data rather than the actual data, because this procedure is not as sensitive to extreme values.

Table 4-20

PERCENT REDUCTION OF SEDIMENTATION PONDS DURING WET AND DRY CONDITIONS

Facility	Pond	Sized to OSM Criterion	Percent Reduction Dry[1]	Percent Reduction Wet[1]
15	1	No	0	27
15	2	No	-233	-147
25	4	No	- 16	68
25	7	No	78	90
33	1	Yes	11.5	68
33	2	Yes	30	38
37	6	No	32	91
38	19	Yes/No	92	92
85	1	No	56	69
101	2	Yes/No	88	92
123	3	No	89	99
181	99	No	95	88
183	1	No	- 67	10
184	7	No	12	33
185	4	No	-179	74
186	2	Yes	-180	34
187	1	Yes	27	99.6
191	18	Yes/No	38	76
191	55	No	- 1	77
Average for "OSM" Ponds			11.4	71
Average for "Non-OSM" Ponds			- 11.6	45.6

[1] A negative values indicates that the effluent was higher than the influent.

the discrete effluent stream. A final mechanism that has been previously alluded to is also possible. Each pond has a theoretical and an actual retention time associated with it, ranging from a few hours to many days. The theoretical retention time is calculated by knowing the pond volume and the average volume of flow into the pond. This theoretical detention often bears little relation to the actual detention time. The actual detention time is defined as the average length of time that a discrete volume (say, one liter) of water enters the pond until that same volume of water exits the pond. It is a complex function of the pond geometry, water temperature, fluid mechanics, and other factors. It will also vary with the volume of inflow to the pond. Obviously, a sampler who collects an effluent aliquot is not accounting for retention time in the pond, which ranged in this study from a few hours to many days. This problem, which is inherent in this type of sampling program, is especially acute during periods of low flow and low TSS concentrations because so little TSS enters the pond. Only small amounts of natural scouring caused by wind and wave action on the surface need to occur to cause the effluent TSS value to be above the influent value.

In recognition of these factors, the ponds exhibiting negative efficiencies were disregarded in further analyses. The remaining ponds were ranked according to effluent mean to assess the importance of the 10-year, 24-hour storm design criterion. These appear in Table 4-21 and 4-22. For dry conditions, five of the seven best performing ponds were sized to OSM criteria. For wet conditions, four of the seven best performing ponds were "OSM ponds." However, as shown in Table 4-22, certain ponds sized to OSM criteria had very high effluent means, suggesting that variables other than size are also extremely important on pond performance. Therefore, it cannot be concluded that "OSM ponds" consistently deliver superior performance.

Table 4-21

RANKED EFFLUENT TSS MEANS FOR DRY CONDITIONS

Facility	Pond	Effluent Mean	"OSM"?
184	7	7	No
38	19	9	Yes
181	99	10	No
191	18	11	Yes
33	1	11	Yes
33	2	14	Yes
187	1	20	Yes
25	7	20	No
123	3	23	No
101	2	29	Yes
85	1	34	No
37	6	41	No

Table 4-22

RANKED EFFLUENT TSS MEANS FOR WET CONDITIONS

Facility	Pond	Effluent Mean	"OSM"?
33	1	12	Yes
33	2	18	Yes
123	3	24	No
184	7	24	No
38	19	25	Yes
181	99	28	No
187	1	29	Yes
191	55	34	No
185	4	58	No
37	6	59	No
15	1	63	No
25	7	74	No
85	1	77	No
191	18	85	Yes
183	1	103	No
25	4	123	No
101	2	162	Yes
186	2	202	Yes

The results of this study support conclusions of previous studies: first, performance of a pond is closely tied to its design and operation; second, total suspended solids of 70 mg/l cannot be consistently achieved during rainfall events; third, TSS variation is quite substantial in treated effluents from areas under reclamation, and cannot be effectively or uniformly regulated in treated runoff from these areas.

APPENDIX A
OF REPORT 1

INSTRUCTIONS FOR COAL MINING INDUSTRY MONITORING PROGRAM AND DATA REQUEST FORMS

ORIGINAL INSTRUCTIONS

COAL MINING INDUSTRY MONITORING PROGRAM

Purpose: To supplement the data base upon which effluent standards will be based for sedimentation structures (i.e., ponds) which handle surface runoff from mining areas and those areas under regrading and revegetation.

Sampling Locations and Pond Selection: Sampling locations will be the influent and effluent of two ponds at surface coal mines owned by your company. The two ponds may be either at the same facility or at different facilities. The ponds selected should be those which handle mostly runoff waters from areas under regrading and revegetation. Each pond selected should not be one that is fed by another pond. Additionally, the ponds should be those that discharge most frequently, even during dry w6ather conditions.

Duration of Sampling: Sampling is to begin within 30 calendar days from receipt of this package and last through March 31, 1980.

Sampling Frequency: A minimum of one sample per week of both influent and effluent of each pond representing "base flow" conditions, i.e., no rainfall, but while the pond is discharging; PLUS, for each rainfall event during the sampling program, two samples each of influent and effluent on the first day of rainfall and two samples each of influent and effluent on the day after the rainfall event ends.

Sample Type: All samples taken for this program will be grab samples.

Parameters for Analysis: All samples taken for this program will be analyzed for the following parameters: Total Suspended Solids, Settleable Solids, Total Iron, Dissolved Iron, and pH. These analyses are to be performed by or arranged (e.g., contracted) for your company. EPA-approved methods are to be used for all analyses. The approved methods are specifie in 40 CFR 136, which are the same methods presently in use by industry for NPDES monitoring.

Flow: Record flow (as gpm) when each sample is taken. Bse weir, etc. measurements if installed and indicate what type of measurement device is installed. If flow is estimated, include a description of the flow estimation technique.

Rainfall Events: Provide the duration (hours) and quantity (inches) of each rainfall event which occurs during the sampling program. Indicate the method used to determine the quantity of rainfall.

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Data Submission: Submit analytical results on a monthly basis (each 30 days) for the duration of the sampling program to:

W.A. Telliard (WH-552)
U.S. EPA
401 M Street, S.W.
Washington, D.C. 20460

Unless you are using these analytical results to also comply with minimum NPDES permit monitoring requirements, you need forward them only to the above individual.

The attached table is to be used to report data. Please be sure to reproduce enough copies of the blank table for use throughout the sampling program.

Sample Shipment to EPA for Analysis

In addition to the previously identified parameters to be analyzed for by each recipient of this package, a split of the following types of samples will be labeled, packaged and shipped to EPA's Denver Surveillance and Analysis laboratory for analysis by EPA:

- One sample each of influent and effluent for each pond every 30 days which was taken during "base flow" conditions (no rainfall).
- One sample each of influent and effluent for each pond every 30 days which was taken during a rainfall event. If, for a given 30 day period, no rainfall occurs by the time the last "base flow" samples are scheduled to be taken, then submit a second set of "base flow" samples.
- Container Type: Poly/Plastic
- Container Size: 500 ml. minimum
- Sample Preservation: None.
- Frequency of Shipment: Within 48 hours of sample collection.
- Method of Sample Shipment: United Parcel Service or equivalent, prepaid.
- Sample Label Information: Preprinted sample labels will soon be sent directly to you. Should you begin sampling for this program prior to receipt of the preprinted labels, please provide your own labels with the following information on them:
  - Company Name
  - Mine Name
  - Pond Identification
  - I = influent sample; E = effluent sample
  - Date Sample Taken
  - R = during rainfall; A = day after rainfall; D = no rainfall
- EPA Laboratory Address:

U.S. EPA
Region 8 Laboratory
Building 53 Entrance W-1 Upstairs
Denver Federal Center
Denver, Colorado 80225

Form Approved
O.M.B. No. 158-R0160

Date______________

Company__________________________

Mine Name__________________________

Pond Name__________________________

Pond Design Criteria: For each pond sampled during this program, provide:

- Pond name or other identification.
- Drainage area - acres
- Drainage area which is disturbed - as acres or % of drainage area
- Average slope of the drainage area
- Cover type on undisturbed portion of the drainage area
- Type of soil/spoil on drainage area, e.g., sandy, silt, loam
- Size of pond - surface area
- Size of pond - volume
- Sketch of pond showing: inflow points, effluent points, shape (attach)
- Depth of pond - average and maximum design
- Type of discharge device
- Design Sediment Storage Volume
- Design detention time

- o Age of pond

- * o Volume of sediment in pond during sampling

- * o Last time pond was cleaned

- * o General condition of pond and other information, e.g., inlet baffle, trees in pond, check dam, etc.

- * o Topographical map of mine area and drainage area (attach)

- o 35 mm slide or glossy photo of each pond (attach).

Note: Submit pond design criteria with the first month's data submissior
Submit asterisked items each month if they change appreciably.

You may respond directly on this form.

CHANGES IN ORIGINAL SELF-SAMPLING AND ANALYTICAL PROGRAM

- This extension applies to the same ponds for which data is currently being submitted.

- This extension expires September 30, 1980.

- Please submit, by May 1, 1980, an update of the pond design parameters indicated in the initial request (included in attached Tab 2). Please also submit the following statistic for each pond:

  The volume attributable to runoff from a 10 year/24 hour storm event for the pond being used in this program. Please show your calculations in the submittal. For purposes of this calculation, a model such as the Water Shed Storm Hydrograph, Penn State Urban Run-Off Model, or similar model may be used. Alternatively, the following may be used:

$$V = \frac{P}{12} \times \left[(A_1 \times C_1) + (A_2 \times C_2) \right]$$

where:
- V is volume in cubic feet
- P is the 10 year/24 hour precipitation event, in inches
- A_1 is the area of the active area drained to the pond, in acres
- C_1 is the run-off coefficient for the active area drained to the pond
- A_2 is the area of the drainage area which comingles with drainage from the active area, in acres. This includes runoff from virgin areas and areas under reclamation which drain to the pond.
- C_2 is the runoff coefficient for areas corresponding to A_2

The following may be used to determine C_1 and C_2 :

	Sandy Loam	Clay & Loam	Clay
Active Mining Area	0.3	0.5	0.6
Virgin land and land under reclamation	0.1	0.3	0.4

The above values are increased by 0.1 for slopes ranging from 5% to 10%, and increased by 0.2 for slopes ranging from 10% to 30%.

- For each sample taken during a rainfall event, indicate when sampling was performed. Example: 1 hr. & 15 min. after start of 20-hour rainfall which totalled 2.1 inches.

- We would appreciate, if you have not already done so, the submittal of transparencies (slides) of your ponds used in this program. This is directed to those several participants who submitted prints with the first submittal of pond data.

- 50 sample labels and 50 mailing labels are enclosed for shipment of samples to EPA's Denver laboratory for the period covered by this extension.

STATEMENT CONCERNING CONFIDENTIALITY AND EPA'S STATUTORY AUTHORITY

This request for information is made under authority provided by Section 308 of the Federal Water Pollution Control Act, 33 U.S.C. §1318. Section 308 provides that: "Whenever required to carry out the objective of this Act, including but not limited to ... developing or assisting in the development of any effluent limitation ... pretreatment standard, or standard of performance under this Act" the Administrator may require the owner or operator of any point source to establish and maintain records, make reports, install, use and maintain monitoring equipment, sample effluents and provide "such other information as he may reasonably require." In addition, the Administrator or his authorized representative, upon presentation of credentials, has right of entry to any premises where an effluent source is located or where records which must be maintained are located and may at reasonable times have access to and copy such records, inspect monitoring equipment, and sample effluents.

Information may not be withheld from the Administrator or his authorized representative because it is confidential. However, when requested to do so, the Administrator is required to consider information to be confidential and to treat it accordingly if disclosure would divulge methods or processes entitled to protection as trade secrets. EPA regulations concerning confidentiality of business information are contained in 40 CFR Part 2, Subpart B, 41 Federal Register 36902-36924 (September 1, 1976). These regulations provide that a business may, if it desires, assert a business confidentiality claim covering part or all of the information furnished to EPA. The manner of asserting such claims is specified in 40 CFR §2.203(b). Information covered by such a claim will be treated by the Agency in accordance with the procedures set forth in the Subpart B regulations. In the event that a request is made for release of information covered by a claim of confidentiality or the Agency otherwise decides to make a determination whether or not such information is entitled to confidential treatment, notice will be provided to the business which furnished the information. No information will be disclosed by EPA as to when a claim of confidentiality has been made except to the extent and in accordance with 40 CFR Part 2, Subpart B. However, if no claim of confidentiality is made when information is furnished to EPA, the information may be made available to the public without notice to the business.

Effluent data (as defined in 40 CFR §2.302(a)(2)) may not be considered by EPA as confidential. In addition, any information may be disclosed to other officers, employees or authorized representatives of the United States concerned with carrying out the Federal Water Pollution Control Act or when relevant in any proceeding under this Act.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

21 AUG 1980

TO PARTICIPANTS IN THE COAL MINING INDUSTRY MONITORING PROGRAM

To fully evaluate the performance of each of the sedimentation ponds being sampled in this program, the origin of wastewater to be treated by the pond is an important factor. Accordingly, we are requesting that each participant provide the following information for each sedimentation pond sampled:

- Area draining to the pond from reclaimed areas, acres;
- Area draining to the pond from virgin areas, acres;
- Area draining to the pond from actively mined areas, acres; and
- Estimate of the percentage of the total wastewater volume from each of the above three areas.

Also, please ensure that all requested data items on the monthly submittal forms are completed, e.g., rainfall data is often missing on the submitted forms.

Thank you for your continued cooperation with this program. Please call me if you have any questions concerning this request or on the program in general.

William A. Telliard, Chief
Energy and Mining Branch
Effluent Guidelines Division (WH-552)
(202) 426-4617

APPENDIX B
OF REPORT 1

POND VOLUME CALCULATIONS

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Sample Calculation - Method 1

Facility 192
Campbell County, Wyoming
Sedimentation Trap #4 (Soil Type estimated as C)

Using curve numbers from Table 4-3, the composite curve number is obtained as follows:

Type of Land Cover	Area (Acres)	Individual CN	Fractional Area	Composite CN
Pond	2.22	100	0.027	2.7
Range	41	79	0.500	39.5
Revegetated - Seeded	38.78	80	0.473	37.8
Total	82.00		1.000	80.00

Thus, the composite curve number is 80.0 for this drainage area. A 10-year, 24-hour storm for facility 192 is 2.5 to 3.0 inches of precipitation. For 2.5 inches, Table 4-4 shows that 0.89 inches of runoff reach the sedimentation basin.

The runoff volume is then calculated as follows:

V = A x R/12

= (82 acres) x (0.89 in./12 inches/ft.)

= 6.08 acre-feet

The above runoff volume corresponds to the pond volume required to contain a 2.5 inch precipitation event at facility 192. Therefore, the required pond volume for a 10-year, 24-hour storm event (i.e., 2.5 to 3.0 inches) for pond 4 at facility 192 is 6.08 to 8.54 acre-feet.

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Runoff volume may also be determined using the following equation:

$$V = P/12 \times [(A_1 \times C_1) + (A_2 \times C_2)]$$

where:

- V is the volume, in acre feet.
- P is the precipitation event, in inches.
- A_1 is the active area (i.e., the area being actively mined) draining to the pond, in acres.
- C_1 is the runoff coefficient for the active area.
- A_2 is the drainage area which commingles with drainage from the active area, in acres. This includes runoff from virgin areas and areas under reclamation which drain to the pond.
- C_2 is the runoff coefficient for areas which commingle drainage from the active area.

The following may be used to determine C_1 and C_2:

	Sandy Loam	Clay and Loam	Clay
Active Mining Area	0.3	0.5	0.6
Virgin Land and Land Under Reclamation	0.1	0.3	0.4

The above values are increased by 0.1 for slopes ranging from 5 to 10 percent, and increased 0.2 for slopes ranging from 10 to 30 percent.

Since seven of the ponds involved have drainage areas with slopes much steeper than 30 percent, the first method is applied in order to keep the calculations on a uniform basis.

REPORT 2

REASSESSMENT OF THE SELF-MONITORING DATA BASE ACCORDING TO THE AMENDED 10-YEAR, 24-HOUR POND DESIGN VOLUME FOR COAL MINES

September 1982

Prepared by:

Allison Phillips
Effluent Guidelines Division
Office of Water Regulations & Standards
U.S. EPA
Washington, D.C. 20460

PURPOSE

The treatment facility design volume necessary to qualify for alternate effluent limitations during precipitation events was amended on May 29, 1981 to that proposed on January 13, 1981 for the coal mining regulations. This amendment modified the design volume of a pond by excluding from consideration waters from undisturbed areas which drain into the treatment facility.

The self-monitoring survey established the data base in support of the 0.5 ml/l settleable solids effluent limitation for coal mines during precipitation events and for reclamation areas. Analyses of the results of this survey were completed before the amended definition for a pond size was proposed. Thus, the technology basis in support of the 0.5 ml/l limitation was a 10-year, 24-hour pond according to the January 13, 1981 proposal. Therefore, the data had to be reevaluated after the amendment to reflect the new pond size definition. The analysis to assess the number of 10-year, 24-hour ponds (according to the new definition) is presented below:

ANALYSIS:

Pond design data and factors used to determine the required pond size are taken from Report 1 of this Appendix.

Assumptions - 1) The curve (CN)* numbers are averaged for each type of land cover according to soil group (See Table 1).

2) All "disturbed areas" are equal to "regraded or revegetated" land as presented in the CN land cover groups.

3) All "actively mined areas" are equal to "cleared unvegetated" land as presented in the CN land cover groups.

Data from Table 4-2 in Report 1 was used to calculate the "new" 10-year, 24-hour ponds. The calculations were performed according to the example in Appendix B of Report 1 except that the virgin land areas were deleted from consideration.

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*Upper or lower limits were calculated wherever it was unnecessary according to comparison with the actual volume. (For example, for pond 25-7 where the actual volume is 1.5 and the lower limit for the required volume is 10.13, the upper limit does not have to be calculated in order to determine whether or not the pond is a 10-year, 24-hour pond .)

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An example calculation is given below:

Facility 15-1
Soil type estimated as B-C.

Using averaged curve numbers from Table 1, the composite curve number is obtained as follows:

Type of Land Cover	Area (Acres)	Individual CN	Fractional Area	Composite CN
Pond	.44	100	.024	2.4
Disturbed	18.06	77	.976	75.2
	18.50		1.0	77.6

Thus, the composite curve number is 77.6 or 78 for this drainage area. A 10-year, 24-hour storm for facility 15-1 is 3.5-4 inches of precipitation as shown in Table 4-2 of Report 1. For 3.5 inches, Table 4-4 of Report 1 shows that 1.52 inches of runoff reach the sedimentation basin.

The runoff volume is then calculated as follows:

$$\begin{aligned} V &= A \times R/12 \\ &= (18.5 \text{ acres}) \times (1.52 \text{ in}/12\text{in/ft}) \\ &= 2.34 \text{ acre feet} \end{aligned}$$

The above runoff volume corresponds to the pond volume required to contain a 3.5 inch precipitation event at facility 15-1. Therefore, the required pond volume for a 10-year, 24-hour storm event (i.e., 3.5-4.0 inches) for this pond is 2.34 to 2.91 acre feet.

Table 4-5 of Report 1 shows that the actual pond volume for facility 15-1 is 2.5 acre feet. This is within the required pond volume of 2.34 to 2.91 acre-feet and thus, this pond is considered to be a 10-year, 24-hour pond.

RESULTS:

All the ponds were evaluated according to the above calculations which resulted in the 11 ponds determined to be 10-year, 24-hour ponds as shown in Table 2.

TABLE 1

RUNOFF CURVE NUMBERS

Land Cover	Condition	Soil Group A	A-B*	B	B-C	C	C-D	D
Regraded - Revegetated								
Close Seeded Legumes	Poor	63	68	73	78	80	82	83
(Contoured & Terraced)	Good	51	55	67	72	76	79	80
Small Grains	Poor	61	67	72	76	79	81	82
(Contoured & Terraced)	Good	59	65	70	74	78	80	81
Row Crops	Poor	66	70	74	77	80	81	82
(Contoured & Terraced)	Good	62	66	71	75	78	80	81
Fallow	--	77	80	86	90	91	93	94
	Ave.**	63	67	73	77	80	82	83
Cleared Unvegetated								
Dirt Roads	--	72		82		87		89
Hard Surface Roads (or Pit)	--	74		84	87	90		92
Paved Surfaces	--	98		98		98		98

*Where "A-B" soil type was submitted, the median curve number between soil types was calculated and used in the averaging.

**These average curve numbers were used in the calculations.

Source: Skelly and Loy Engineers, A Compliance Manual--Methods for Meeting OSM Requirements, McGraw-Hill, Inc., New York, New York, 1979, p. 6-32.

TABLE 2

10-Year, 24-Hour Ponds

Pond	Actual Volume	Required Volume	10-Year, 24-Hour Pond?
15-1	2.6	2.34 - 2.91	yes
15-2	1.6	1.26 - 1.58	yes
25-3	No data submitted on design		no
25-4	1.3	4.74 - 5.91	no
25-7	1.5	10.13 - *	no
33-1	48.5	- 3.08	yes
33-2	19.4	- 7.18	yes
37	32.2	47.6 - 67.4	no
38	28.6	- 13.18	yes
85	16.2	17.34 - 24.02	yes**
101	28.2	- 19.16	yes
123	215	- 197.58	yes
181	3.9	6.89 - 8.27	no
182-1	13.5	- 5.35	yes
182-2	10.0	- 3.50	yes
183	3.1	4.14 - 5.48	no
184	1.9	2.05 - 2.55	yes**
185	6.6	7.40 - 9.15	no
186	3.3	- 2.29	yes
187	20	- 12.37	yes
191-55	125	104.46 - 129.5	yes
191-18	20	15.83 - 20.19	yes
192-4	13.6	4.51 -	yes
192-6	16.8	1.79 - 2.26	yes

---

*Upper or lower limits were calculated wherever it was unnecessary according to comparison with the actual volume. (For example, for pond 25-7 where the actual volume is 1.5 and the lower limit for the required volume is 10.13, the upper limit does not have to be calculated in order to determine whether or not the pond is a 10-year, 24-hour pond.)

**An error of at least 10% is assumed in these calculations because of the 1) vast amount of land involved, 2) difficulty in determining pond depth and therefore pond volume, 3) difficulty in determining precise amount of runoff, 4) error in precipitation estimates for 10-year, 24-hour storms.

REPORT 3

STATISTICAL SUPPORT FOR THE PROPOSED EFFLUENT LIMITATION OF 0.5 ml/l FOR SETTLEABLE SOLIDS IN THE COAL MINING INDUSTRY

September 1982

Prepared by:

Office of Analysis and Evaluation
Office of Water Regulations and Standards
U.S. EPA
Washington, D.C. 20460

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DATE: SEP 28 1982

SUBJECT: Statistical Support for the Proposed Effluent Limitation of 0.5 ml/l for Settleable Solids in the Coal Mining Industry

FROM: R. Clifton Bailey, Statistician RCB
Program Integration and Evaluation Staff (WH-586)

TO: Allison Phillips, Project Officer
Energy and Minerals Branch (WH-552)

Analysis of the data for settleable solids from the coal mining industry confirms the proposed limitation of 0.5 ml/l is consistent with Agency policy for effluent guidelines. The limitation is supported by data from sedimentation ponds which serve active mine areas and/or reclamation areas and met the size criterion as specified in the May 26, 1981 amendment to the coal mining effluent guidelines regulations proposed on Jaunary 13, 1981. The settleable solids limitation applies at active mine sites to effluent affected by precipitation events and at reclamation sites to effluent regardless of weather conditions. Reclamation area discharges are minimal during dry weather conditions so that effluent discharge occurs almost exclusively as the result of run off from precipiation. The data and analysis that support the limitations are described in this memorandum.

Data

The data used here were obtained in a one year self monitoring study of the coal mining industry. The study was conducted to obtain data that would support an evaluation of the effluent limitation proposed for settleable solids. A total of 24 sedimentation ponds were included in the self monitoring study. These ponds were selected to span the range of geographical and operational conditions in the indsutry. A comprehensive summary of the design and operation of the 24 ponds is contained in Coal Mining Industry Self-Monitoring Program, Radian Corporation, May, 1981. Data were collected at these ponds from September, 1979 to September, 1980 and classified as either "wet conditions" or "dry conditions." "Wet conditions" refers to data collected on the day of and day immediately following a precipitation event while "dry" refers to data collected at other times. The evaluation of the proposed limitation of 0.5 ml/l for settleable solids is based on the observations taken only during wet conditions because the limitation applies at active mine effluents affected by precipitation events and, although reclamation areas are subject to the limitation under all weather conditions, only during wet conditions are they likely to have an effluent discharge.

The Imhoff cone method was used to measure settleable solids in the self-monitoring study. The method is described in Standard Methods for the Examination of Water and Wastewater and 304(h) of the EPA's "Methods for Analysis of Water and Wastewater" as having a "practicable lower limit of measurement" of "about 1 ml/l." The proposed limitation of 0.5 ml/l is below this value. In fact, all facilities with effluent discharge in the self monitoring study reported values well below 1.0 ml/l. Consequently, a study was conducted to examine the detection limit for settleable solids using the Imhoff cone method

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on coal mining effluent. The study is described in Coal Mine - Drainage Precision and Accuracy Determination for Settleable Solids at Less Than 1.0 ml/l, prepared for EPA by Hydrotechnic Corporation, August, 1982. The study involved field and laboratory determinations of the method detection limit using samples collected at 8 different sedimentation ponds. The study followed the procedure described in "Definition and Procedure for the Determination of the Method Detection Limit" [1/21/81 Revision 1.11, by EMSL-CI, EPA]. There were 8 field determinations (one from each pond) of the method of detection limit which ranged from 0.04 ml/l to 0.40 ml/l with an arithmetic average of 0.22 ml/l. A total of 10 laboratory determinations were made (at least one from each pond) which ranged from 0.05 ml/l to 0.20 ml/l with an arithmetic average of 0.12 ml/l. The results of this study support the conclusion that it is possible to measure settleable solids values below 1.0 ml/l. As a result of this study the method detection limit for settleable solids in coal mining was set conservatively to be 0.4 ml/l, the maximum of the field determinations.

The self-monitoring data are summarized by pond in Table 1. The ponds are identified by a facility number F and a pond number P as F.P. Thus, for example, pond 2 at facility 15 is designated by 15.2. These data were evaluated and several adjustments were made for the purpose of analyzing the proposed limit. Ponds 101.2 and 191.55 were excluded from the evaluation of the limitation because of design and operational defects as described in the Radian Report and further documented in the Record (Memo to the Effluent Guidelines Division from Radian: Marc Papai to Allison Wiedeman, September 21, 1982). Four ponds that were included in the study, 182.1, 182.2, 192.4 and 192.6 had no discharge and thus yielded no effluent data. One of the twenty-three ponds originally selected for study, pond 25.3 was taken out of operation in March 1980 and replaced by pond 25.4. In some cases, duplicate observations on the same day were reported at ponds 25.3, 25.4, 25.7, 37.6, 184.7 and 185.4. These values were below the proposed limitation of 0.5 ml/l or reported as nondetect (ND) or trace (TR). In Table 1 these duplicates have been counted as a single determination for that day. This approach is conservative and consistent with the study protocol. Counting the duplicates as separate observations would give the misleading appearance of higher rates of compliance since these values were below the proposed limit. Values reported as trace (TR) were not counted as exceeding the limit. For pond 37.6, several measurements of "ND 1" were reported during wet conditions. This is a convention for identifying measurements below 1 ml/l. No additional values were reported in this manner after June 12, 1980. Values of ND 0.1, 0.15, and 0.3 ml/l were also reported for this pond. The observations reported as ND 1 have been counted as not exceeding the proposed limitations of 0.5 ml/l.

Analysis

The objective of this analysis is to establish whether the proposed limitation is consistent with the usual Agency policy of 99% compliance for effluent limitations guidelines. That is, if the data demonstrate that 0.5 ml/l is met roughly 99% of the time by sedimentation ponds that satisfy design criteria, then the proposed limit is a reasonable regulatory value.

TABLE 1

FREQUENCY OF EFFLUENT SETTEABLE SOLIDS VALUES (ml/l) EXCEEDING THE 0.5 ml/l LIMITATION AS REPORTED BY COAL MINING FACILITIES DURING WET CONDITIONS

Pond	# of Observations > 0.5	Total # of Observations
*15.1	2	13
*15.2	0	12
25.3	0	3
25.4	0	13
25.7	0	16
*33.1	0	66
*33.2	0	65
37.6	0	17
*38.19	0	5
*85.1	0	30
°*101.2	5	42
*123.3	0	6
181.99	0	63
†*182.1	0	0
†*182.2	0	0
183.1	1	16
*184.7	0	30
185.4	2	24
*186.2	0	12
*187.1	0	12
*191.18	2	11
°*191.55	1	11
†*192.4	0	0
†*192.6	0	0
TOTAL	13 (7) ((4))	467 (414) ((262))

* Satisfies size criterion.

† No discharge.

° Deleted from analysis (see text).

() Values in parentheses are totals with ponds 101.2 and 191.55 deleted.

(()) Values in double parentheses are totals for ponds which exceed size criterion with ponds 101.2 and 191.55 deleted.

The data shown in Table 1 provide the basis for the analysis of the proposed limitation. The number of measurements from each pond is variable because the precipitation events for each pond vary. Data such as this are referred to as clustered, i.e., the sampling days are clustered by pond. If the proportion of sampling days with values exceeding 0.5 ml/l is roughly 1% or less, then the proposed limit would be consistent with the 99% compliance criterion. The estimation of proportions for clusters is discussed in Cochran, W.G., Sampling Techniques, 2nd Edition, Wiley and Sons, 1963, pp. 64-70. The analysis employed here follows Cochran's recommendations.

The overall proportion, p, exceeding the limit is estimated by

$$\hat{p} = X/N,$$

where X is the total number of observations exceeding the limit and N is the total number of observations over all ponds. The variance of p is approximated by

$$V(\hat{p}) = \frac{1}{k} \sum_{i=1}^{k} \left(\frac{n_i}{\overline{n}}\right)^2 \frac{(p_i - \hat{p})^2}{k-1}$$

where

k = total number of ponds,
n_i = number of observations at the ith pond,
p_i = proportion of observations exceeding the limit at the ith pond,
$\overline{n}$ = average number of observations per pond
$= \sum_{i=1}^{k} n_i/k.$

The square root of this variance is the estimate of the standard error of $\hat{p}$, denoted by S.E.($\hat{p}$).

The sample proportion p is compared to 0.01 using the following test statistic

$$Z_o = (\hat{p} - 0.01)/S.E.(\hat{p}).$$

If $\hat{p}$ is substantially greater than 0.01, Z_o will be a large positive number. Using the normal distribution to approximate the distribution of Z_o, the probability of exceeding a particular value of Z_o may be calculated. If the probability of exceeding an observed (i.e., a value calculated from the data) value of Z_o is small (less than 0.05), then the observed rate of exceedance for the proposed limit would be significantly different from 0.01 and the 99% compliance criterion would not be satisfied.

Analysis for Ponds Meeting the Size Criterion

Eleven ponds with effluent discharge data met the size criterion (see Table 1). For these ponds there were a total of 262 observations of which only 4 exceeded 0.5 ml/l. That is, 98.47% of the observations satisfy the proposed limitation. The formulas given above were used to estimate the proportion p exceeding 0.5 ml/l and the standard error of $\hat{p}$. The estimates are

$$\hat{p} = 4/262 = 0.0153$$

and

$$S.E. (0.0153) = 0.0121.$$

The value of the test statistic is

$$Z_0 = (0.0153 - 001)/0.0121 = 0.44.$$

The probability of exceeding this value for Z_0 is approximated by

$$\text{Probability} \{ Z > 0.44 \} = 0.330$$

where Z is a standardized normal variate (Tabled values for standardized normal variates are given in most statistics texts. See, for example, Walpole, R.E. and R.H. Myers, Probability and Statistics for Engineers, 2nd Edition, MacMillian, 1978, Table IV, p. 513). Since the probability associated with the observed value of Z_0 for the ponds meeting the size criterion is not small, the data do not demonstrate an exceedance rate for the proposed limit that is significantly different from 0.01. Therefore, the data support the conclusion that the 0.5 ml/l value is consistent with the 99% compliance criterion.

Analysis of Ponds Without Regard to Size Criterion

When pond size is disregarded, the data still show a high rate of compliance with the proposed limit of 0.5 ml/l. This result is based on the analysis of the data for a total of seventeen ponds, without regard to size, (see Table 1; NB, data for 25.3 and 25.4 were combined because one was a replacement for the other). From the 17 ponds there are a total of 414 observations of which 7 exceeded the limit. That is, 98.31% of the observations satisfy the proposed limitations. Now the estimate of the exceedance rate $\hat{p}$ is

$$\hat{p} = 7/414 = 0.0169$$

with

$$S.E. (0.0169) = 0.00939.$$

Thus,

$$Z_0 = (0.0169 - 0.01)/0.00939 = 0.73$$

and

$$\text{Probability} \{ Z > 0.73 \} = 0.233.$$

Therefore, when data from all ponds without regard to size are considered, the observed exceedance rate is not significantly different from 0.01 and the proposed limit is judged to be consistent with the 99% compliance criterion.

Conclusions

Analysis of the available settleable solids data from coal mining sedimentation ponds demonstrates that the proposed limit of 0.5 ml/l is consistent with Agency policy for effluent guidelines of 99% compliance. Statistical analysis shows that the observed exceedance rate is not significantly different from 1%. This conclusion holds regardless of whether or not the size criterion for ponds specified in the proposed regulation is considered. Therefore, the 0.5 ml/l settleable solids value is a reasonable and practicable limitation.

APPENDIX B

COAL MINE DRAINAGE -
PRECISION AND ACCURACY DETERMINATION
FOR
SETTLEABLE SOLIDS AT LESS THAN 1.0 ml/l

COAL MINE - DRAINAGE
PRECISION AND ACCURACY DETERMINATION
FOR
SETTLEABLE SOLIDS AT LESS THAN 1.0 ML/L

Prepared for:

U.S. Environmental Protection Agency

Effluent Guidelines Division

Energy and Mining Branch

401 M Street, S.W. (WH-552)

Washington, D.C. 20460

August 1982

Prepared by:

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New York, New York

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I. Background

In the proposed Coal Mining Point Source Category Effluent Limitations Guidelines (40 CFR Part 434, May 29, 1981), Sections 434, 52, 53, 55 and 63, prepared by the U.S. Environmental Protection Agency, a limit of 0.5 ml/l for settleable solids was specified for discharges from reclamation areas for BPT, BAT, NSPS and during precipitation events for active area surface drainage. This limit of 0.5 ml/l was established based on the results of self-monitoring programs in which various mines sent settleable solids effluent data to the U.S. EPA. Settleable solids readings ranged from "0" to 1.0 ml/l.

The method employed to measure settleable solids is the volumetric method outlined in Standard Methods and 304 (h) of the Agency's "Methods for Analysis of Water and Wastewater." However, the method for settleable matter determination, specified in these publications, states that "the practical lower limit of measurement is about 1 ml/l."

The purpose of this study was to further investigate the precision and accuracy of measuring settleable solids below 1.0 ml/l. The results determined the method detection limit for settleable solids to be 0.4 ml/l.

Purpose

In order to determine the variability and repeatability of settleable solids measurements around 0.5 ml/l, a test program was planned to develop a precision and accuracy determination for the measurement of less than 1 ml/l of settleable solids for active area and reclamation area discharges from coal mines.

Eight pond influents and effluents were sampled and settleable solids tests were run for each pond. Since overflows during rainfall periods could not be practically obtained, pond influents were used to spike pond effluents in order to obtain settleable solids of less than one ml/l for the purpose of this determination. Concurrent measurements and statistical analyses were also conducted on the samples by the Agency's Environmental Monitoring and Support Laboratory in Cincinnati, Ohio.

III. Procedures

To determine the variability at levels around 0.5 ml/l settleable solids, a certain analytical and statistical methodology was employed. This program involved taking eight samples from various mine drainage and mining activities (varying in geographical and soil characteristics, etc.) which were collected for study and measurement. Seven replicates of each sample were measured simultaneously in the field. The samples were also measured for pH. In cases where the effluent levels from either settling ponds or mine drainage treatment facilities were significantly less tha 0.5 ml/l, the influent was used to spike the effluent to provide a level of effluent within the desired range for determining variability, precision, and accuracy. The replicates of each sample were then recombined into one container and shipped to the Cincinnati Laboratory in 7 to 8 liter volumes. The laboratory then also ran seven replicates on each sample by the volumetric method.

The industry was contacted prior to this study and, in most cases, made concurrent measurements in the field. This provided three independent measurements, in the field, for most samples.

The analytical method was as specified in the EPA adopted Standards Methods procedure for settleable matter (See Reference 1). This method employs an Imhoff cone (illustrated in Reference 2) for analysis. All the field data was forwarded to the Environmental Monitoring and Support Laboratory in Cincinnati (EMSL) where standard calculations were performed to determine the lower levels of detection and variability. The same statistics were performed on the laboratory results. The calculation procedures are described in Reference 3.

IV. Mine Ponds

Three mine ponds in the East and five in the West were tested.

Eastern Mines

Mine Pond No. 1 - The pond is a preparation plant slurry pond associated with a surface mine and is located in Central West Virginia.

Mine Pond No. 2 - The pond is a silt control structure downstream of a slurry dam located at a deep mine site in West-Central Ohio.

Mine Pond No. 3 - The pond is used to settle treated AMD and is located in West-Central Pennsylvania.

Western Mines

All ponds tested were located in North Western Colorado.

Mine Pond No. 4 - The pond collects water mainly from a reclamation area. Some water also enters from a disturbed area.

Mine Pond No. 5 - This pond collects runoff from an active mining area and from surrounding disturbed areas.

Mine Pond No. 6 - Two ponds receive water discharging from a coal crusher building and the area around the building.

Mine Pond No. 7 - This pond receives runoff from a partially revegetated reclamation area. The flow enters the pond from various drainage ditches.

Mine Pond No. 8 - Water from an active area is pumped to this pond and runoff from a reclaimed area is also collected in the pond. The water from this pond discharges to a secondary pond before final discharge to the receiving waters.

V. Results

A summary of the results obtained in the field and in the laboratory are presented in Table I. The complete data is presented in References 4 and 5. It can be seen that the values obtained in the field were higher than the laboratory results in all but one case. This difference, in the case of the higher field values, was probably due to the physical set-up for obtaining the results in the field. The field set-up was rather crude and the Imhoff cone holder may not have been perfectly level when the tests were run.

In addition, a magnetic stirrer was not available for mixing the sample and, in accordance with Standard Methods, the cones were only stirred once after forty-five minutes to loosen solids which had deposited on the sides of the cone. No attempt at "leveling" was made in the field. The leveling procedure, described in Appendix B, could have had the effect of reducing the effects of hindered settling, thus reducing the apparent amount of settleable solids present.

For Mine Pond No. 3, the field measurements of settleable solids were significantly lower than the laboratory readings. This pond was used to settle neutralized acid mine drainage in contrast to the other ponds which removed solids carried by storm runoff and dry weather drainage. The neutralized AMD effluent contains iron hydroxides which, under certain conditions, form a voluminous floc. During the field tests only a "pin-point" floc was observed in the Imhoff cones for Mine Pond No. 3 in contrast to the heavy floc reported for the laboratory results. The heavy floc formed in the laboratory could have been caused by the use of the magnetic stirrers which may have produced a flocculating action. In the field the 2.5 gallon containers were vigorously shaken which probably broke up the floc into pin-point "size".

The "large" floc particles could have caused the hindered settling because of entrainment of water due to the clustering of the large floc particles. In contrast, the pin-point floc may have allowed the water to separate from the settleable solids thus resulting in lower field values.

The difference between the readings of the seven cones for each Mine Pond are apparently greater in the field data then in the laboratory. This is probably due to two reasons, namely; the method of mixing and decanting of the samples to the seven cones was not as precise in the field and the readings taken in the field were, in most cases, to only one significant figure. This "problem" in the field readings is probably more representative of what will happen when actual field samples are taken and measured.

Therefore, we have opted to use only the field results to base our conclusions on. As noted in Table No. 1, the maximum method detection level is 0.40 ml/l/hr. The mean of the standard deviation values is 0.08 ml/l/hr. To obtain a 99% confidence level for both the MDL and the standard deviation, the standard deviation would have to be multiplied by three to obtain a value of 0.24 ml/l/hr. This then affirms a method detection limit of 0.40 ml/l/hr.

Conclusions

Based on field samples and analysis of settleable solids both in the field and in the laboratory, it was determined that values of settleable solids can be read with a reasonable degree of accuracy below 1.0 ml/l/hr using the volumetric method outlined in Standard Methods and 304(h) of the Agency's "Methods for Analysis of Water and Wastewater". This method has been used for years to determine the amount of settleable solids in wastewater. The method states that "the practical lower limit of measurement is about a ml/l" (increments between 0 and 1.0 ml/l) and upon observing the cones it is obvious that readings can be made below the level of 1.0 ml/l. In fact, the method detection limit for settleable solids measurements has been statistically determined by this study to be 0.4 ml/l for the coal mining industry.

TABLE NO. I

SUMMARY OF COAL MINE POND

SETTLEABLE SOLIDS TESTING

		IMHOFF CONE NO.									
Mine Pond No.	Obser.	1	2.	3	4	5	6	7	Mean.	Std. Dev.	MD
1	E	0.7	0.8	0.8	0.7	0.7	0.7	0.7	0.76	0.09	0.23
	C	0.65	0.85	0.8	0.9	0.9	0.75	0.7			
	M	0.8	0.7	0.9	0.7	0.9	0.8	0.6			
	L*	0.40/ 0.50	0.40/ 0.55	0.40/ 0.40	0.38/ 0.50	0.30/ 0.40	0.35/ 0.50	0.38/ 0.40	0.37/ 0.46	0.038/ 0.063	0.12/ 0.20
2	E	0.30	0.30	0.35	0.35	0.35	0.30	0.30	0.36	0.043	0.11
	C	0.40	0.40	0.35	0.35	0.30	0.35	0.35			
	M	0.45	0.40	0.40	0.35	0.40	0.35	0.4			
	L	0.38	0.35	0.35	0.30	0.30	0.25	0.28	0.32	0.046	0.14
3	E	0.1	0.09	0.09	0.09	0.08	0.08	0.07	0.094	0.015	0.04
	C	0.1	0.09	0.09	0.09	0.09	0.09	0.07			
	M	0.13	0.11	0.1	0.1	0.13	0.1	0.09			
	L	0.50	0.55	0.60	0.60	0.50	0.55	0.55	0.55	0.041	0.13
4	E	0.6	0.4	0.6	0.5	0.6	0.7	0.9	0.56	0.16	0.40
	C	0.5	0.4	0.5	0.4	0.6	0.7	0.8			
	M	0.5	0.4	0.5	0.4	0.6	0.7	0.9			
	L	0.58	0.60	0.55	0.65	0.60	0.50	0.55	0.58	0.048	0.15
5	E	0.7	0.7	0.7	0.6	0.5	0.7	0.7	0.65	0.09	0.25
	C	0.7	0.7	0.7	0.5	0.5	0.8	0.7			
	M	-	-	-	-	-	-	-			
	L*	0.50/ 0.45	0.50/ 0.40	0.45/ 0.40	0.45/ 0.40	0.40/ 0.42	0.45/ 0.42	0.40/ 0.40	0.45/ 0.42	0.041/ 0.092	0.13/ 0.070
6	E	0.7	1.0	0.9	0.9	0.8	0.7	0.8	0.82	0.11	0.30
	C	0.7	1.0	0.9	0.9	0.7	0.7	0.8			
	M	-	-	-	-	-	-	-			
	L	0.50	0.45	0.48	0.40	0.40	0.40	0.40	0.43	0.043	0.14
7	E	0.2	0.3	0.4	0.2	0.2	0.3	0.2	0.28	0.08	0.21
	C	0.3	0.3	0.4	0.3	0.2	0.4	0.2			
	M	-	-	-	-	-	-	-			
	L	0.15	0.12	0.10	0.10	0.12	0.12	0.10	0.12	0.018	0.057
8	E	0.3	0.4	0.3	0.4	0.3	0.3	0.5	0.36	0.081	0.20
	C	0.3	0.4	0.3	0.5	0.3	0.3	0.5			
	M	0.3	0.3	0.3	0.4	0.3	0.3	0.5			
	L	0.12	0.15	0.15	0.15	0.12	0.15	0.12	0.14	0.016	0.050

* DUPLICATE TESTS RUN IN LABORATORY

E - EPA, EGD REPRESENTATIVE
C - EPA CONTRACTOR
M - MINE REPRESENTATIVE
L - EPA LABORATORY

REFERENCE 1

SETTLEABLE MATTER PROCEDURE

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From: "Standard Methods for the Examination of Water and Wastewater", 14th edition, 1976, APHA-AWWA-WPLF

208 F. Settleable Matter

1. General Discussion

Settleable matter in surface and saline waters as well as domestic and industrial wastes may be determined and reported on either a volume (milliliters per liter) or a weight (milligrams per liter) basis.

2. Apparatus

The apparatus listed under Sections 208 A.2 and 208 B.2, and an Imhoff cone, are required for a gravimetric test. The volumetric test requires only an Imhoff cone.

3. Procedure

a. By volume: Fill an Imhoff cone to the liter mark with a thoroughly mixed sample. Settle for 45 min, gently stir the sides of the cone with a rod or by spinning, settle 15 min longer, and record the volume of settleable matter in the cone as milliliters per liter. The practical lower limits is about 1 ml/l/hr. Where a separation of settleable and floating materials occurs, do not estimate the floating material.

b. By weight:

1) Determine the suspended matter (in milligrams per liter) in the sample as in Method D, preceding.

2) Pour a well-mixed sample into a glass vessel not less than 9 cm in diameter. Use a sample of not less than 1 l and sufficient to give a depth of 20 cm. A glass vessel of greater diameter and a larger volume of sample also may be used. Let stand quiescent for 1 hr and, without disturbing the settled or floating material or that which may be floating, siphon 250 ml from the center of the container at a point halfway between the surface of the settled sludge and the liquid surface. Determine the suspended matter (in milligrams per liter) in all or in a portion of this supernatant liquor as directed under Method D. This is the nonsettling matter.

4. Calculation

mg/l settleable matter
= mg/l suspended matter
−mg/l nonsettleable matter

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REFERENCE 2

PICTURE OF AN IMHOFF CONE

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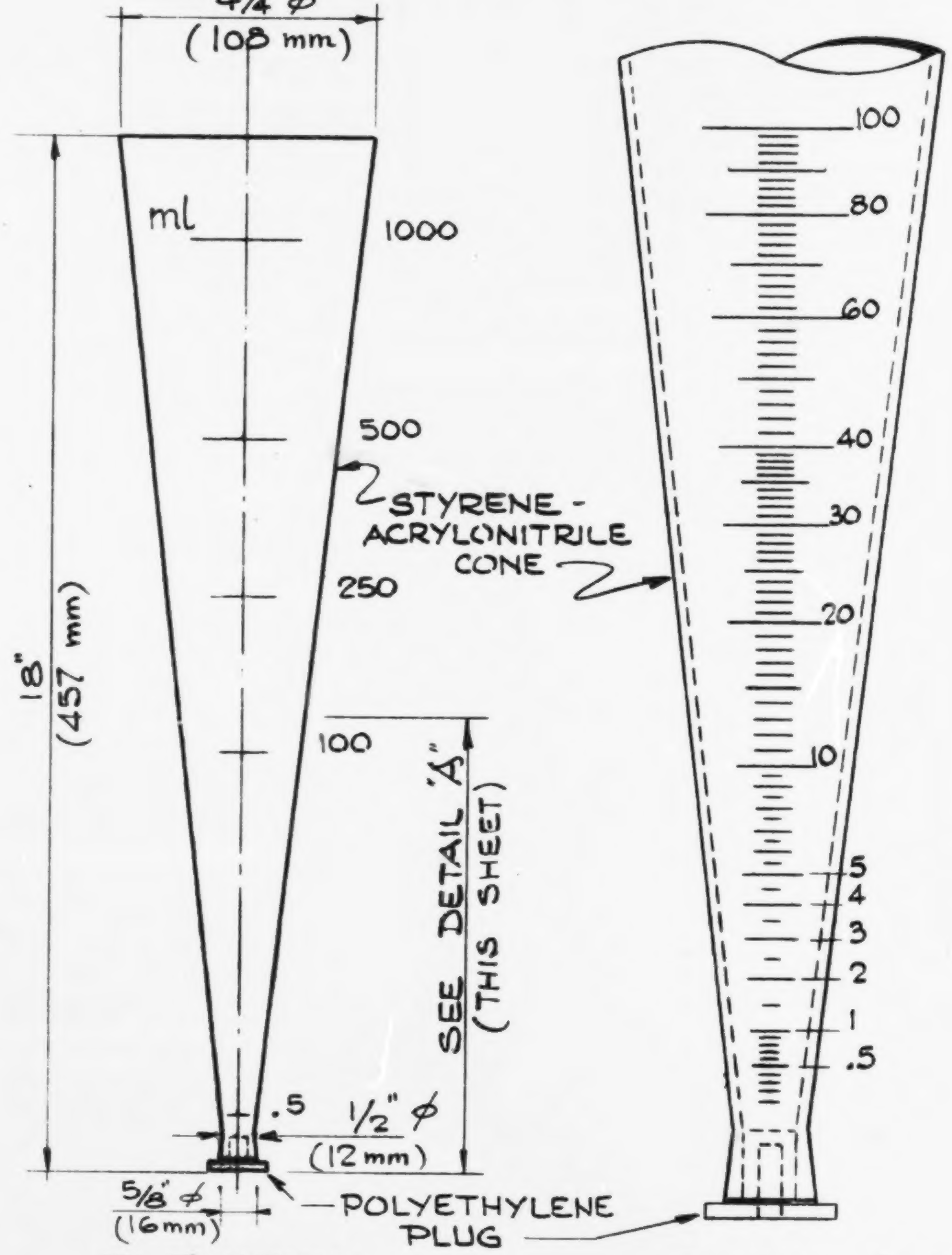
HYDROTECHNIC CORPORATION
NEW YORK, N. Y.



ELEVATION
(3/8" = 1")

DETAIL "A"
(FULL SCALE)

IMHOFF CONE
USED IN COAL MINE SETTLING TESTS

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REFERENCE 3

METHOD DETECTION LIMIT - REFERENCE ARTICLES

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Trace analyses for wastewaters

Method detection limit, a new performance criterion for chemical analysis, is defined as that concentration of the analyte that can be detected at a specific confidence level. Both theory and applications are discussed for reliable wastewater analyses of priority pollutants

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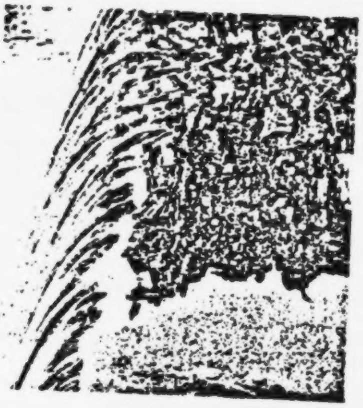
The development of trace analysis methodology brought with it a series of questions about method performance at low concentration levels of analyte (*1, 2, 3*). Under Section 304(h) of the Clean Water Act, as amended in 1977, (*4*) the Environmental Monitoring and Support Laboratory (EMSL) in Cincinnati is responsible for providing test procedures for the measurement of specified pollutants at trace concentrations in municipal and industrial wastewaters.

A series of procedures was published in the Federal Register for the analysis of the 129 priority pollutants (*5*). These procedures are designed to monitor direct discharges from industrial and publicly owned treatment works (POTW), sources under the National Pollutant Discharge Elimination System (NPDES), and discharges into a POTW system under pretreatment regulations. The 304(h) monitoring methods for organic analyses are of two types:

- 12 methods designed around gas–liquid and high performance liquid chromatography with standard detectors and modest operational skill requirements for the permit holder
- three methods that employ a mass spectrometer as a detector for multiple measurements with minimal interference.



To meet the needs associated with these methods for analysis of the priority pollutants, it was incumbent on EMSL to develop method performance characteristics for these methods. As advocated by Wilson (*6*), method performance characteristics are specified criteria that detail the ability of a method to analyze for analyte.

Clearly, analyte detection is a fundamental criterion of performance for an analytical system. Any analytical system is constrained by an inability to discern the signal due to noise from the signal due to the presence of analyte at low concentrations. The limit of detection for a given analyte can be defined as that concentration of the analyte which can be detected at a specific confidence level.

The concept of detection limit has been the focus of debate (*7*). The controversy generally centers on definitions that vary with the analyst (*8*). Confusion arises when instrumental and method detection limits are compared and sometimes used interchangeably (*9*). Moreover, detection and determination have also been conceptually intertwined by some investigators (*10*). Although definitions of the detection limit for a given analyte vary, investigators concur that the detection limit should be related to the standard deviation of the measured values at or near zero concentration of the analyte (*11*).

There is no doubt that the detection limit is one of the most important performance characteristics of an analytical procedure. In most cases, a detection limit must be viewed as a temporary limit to current methodology.

Complete analytical system

Ostensibly, analysts do not directly observe concentrations of analyte. The measurements of the transducer signal, which are related to the analyte concentration, are actually observed. In any analytical system, information concerning the identity and quantity of an analyte is contained in the analytical signal, which depends on a large number of experimental variables. Since these variables contain a random component, the analytical signal will also have a random component characterized by a probable uncertainty. Some part of an averaged signal must be a function of the true analyte concentration. Analysis of the signal precludes the ability of the analyst to discern the fluctuations of the background from the average value of the analytical signal for a given concentration of analyte.

The relationship between background noise and analytical signal has been studied by many authors; their work has helped to develop the definition and evaluation of the detection limit. A point of reference is necessary to specify the sources of background noise contributing to the overall analytical signal. Kaiser (*12*) has been a major figure in this development. He has centered his thoughts on the detection limit of a "complete analytical procedure." Such a procedure or method is specified in every detail by

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fixed working directions (order of analysis) and is directed for use at a particular analytical task. The specifics of a "complete analytical procedure" include a predetermination of everything associated with the analytical task: the apparatus, the external conditions, the experimental procedure, the evaluation of results, and calibration of the analytical system. Thompson and Howarth (*13*) have expanded this concept to develop an analytical system that comprises:

- a set of samples of the analyte in a specific matrix
- an exactly defined analytical procedure
- the particular instrumentation used.

The purpose for developing a procedure to evaluate detection limits was to design a methodology not limited by instrumentation or analytical methodology. For pragmatic reasons, we focused on an operational definition of detection limit. The analytical methodology for priority pollutants served as a basis for the concepts concerning the method detection limit (MDL). Each of the methods comprising this methodology is designed to constitute a "complete analytical procedure" or "complete analytical system." Integral to these concerns was an attempt to specify a parameter for performance measurement of each method of analysis.

The method detection limit refers to samples processed through all the steps comprising an established analytical procedure. The fundamental difference between our approach to detection limit and former efforts is the emphasis on the operational characteristics of the definition. MDL is considered operationally meaningful only when the method is truly in the detection mode, i.e., analyte must be present. *The method detection limit is defined as the minimum concentration of a substance that can be identified,*

Theory

The MDL can be presented as an error distribution. The definition of MDL implies that, on an average, 99% of the trials measuring the analyte concentration at the MDL must be significantly different from zero analyte concentration. A one-sided test is performed to evaluate this hypothesis.

This graphical description of MDL is based on the assumptions that the error distribution associated with the analytical measurement, in a sufficiently large neighborhood proximate to the MDL, has a relatively homogeneous variance and is normally distributed. A sufficiently large neighborhood is specified to accommodate our recommendations for the initial estimate of the MDL.

Basic to these concepts is the assumption that the variability of an analytical measurement, as measured by the standard deviation σ_C, is a function of the concentration being measured $\sigma_C = f(C)$. Experience has shown that the variance is relatively homogeneous over a relatively large concentration range. Alternatively, one may say that the variability is reasonably smooth over the linear range of an analytical method. Such a functional response can be approximated by a polynomial of degree *N*.

$$\sigma_C = k_0 + k_1C + k_2C^2 \ldots + k_NC^N \quad (1)$$

Since economic considerations demand that the MDL be determined with a limited number of analyses, the standard deviation S_c employed in these calculations is an estimate of the population standard deviation σ_C. If the mass of the standard addition (spike) is measured accurately, the coefficients and intercept for the polynomial model may be estimated by linear regression. This model can be truncated to a first order equation:

$$S_c = k_0 + k_1C \quad (2)$$

The form of the error distribution associated with these considerations is irrelevant, but we assumed that the number of independent error components, associated with most analytical systems, will be large enough to invoke the central limit theorem. Therefore, the normal distribution will be a good approximation of the error distribution associated with any analytical determination (*16, 17*).

To help avoid a negative estimate of k_0, the regression equation can be transformed by dividing through by C.

$$\frac{S_c}{C} = \frac{k_0}{C} + k_1 \quad (3)$$

A regression on S_c/C vs. $1/C$ will yield the estimated slope k_0 and the intercept k_1. The estimate of the slope should be less sensitive to nonrandom errors than the intercept estimate. Hence, a negative estimate of k_0 often may be avoided.

Since a limited number of samples will be taken at each concentration, the error distribution of this sampling is expected to be approximated by a student's *t* distribution. By defining t_c as:

$$t_c = \frac{C}{S_c/(N)^{1/2}} \quad (4)$$

then

$$\frac{(N)^{1/2}}{t_c} = \frac{S_c}{C} \quad (5)$$

and the regression equation becomes:

$$\frac{(N)^{1/2}}{t_c} = \frac{k_0}{C} + k_1 \quad (6)$$

The regression equation is now in a form compatible to find MDL, such that

$$t_c \approx t_{(N-1\ df,\ 1-\alpha=.99)}$$

or

MDL

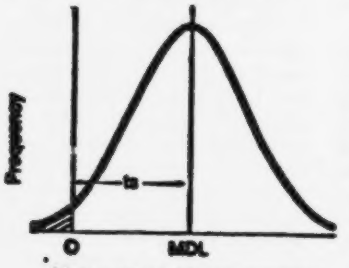
$$= \frac{t_{(N-1\ df,\ 1-\alpha=.99)}\, k_0}{(N)^{1/2} - k_1 t_{(N-1\ df,\ 1-\alpha=.99)}} \quad (7)$$

It must be emphasized that k_0 is conceptually no longer the sample standard deviation at zero concentration, a concept which necessitates the possibility of negative analytical responses at zero concentration of analyte. Now k_0 is the linear trend in the regression of $(N)^{1/2}/t_c$ vs. $1/C$, which in practical terms means that analytical responses at zero concentration are not necessary or implied in the determination of MDL. For obvious economic reasons, the equation for MDL can be reduced to:

$$\text{MDL} = t_{(N-1\ df,\ 1-\alpha=.99)} S_c \quad (8)$$

by setting the intercept k_1 to be equal to zero and setting $k_0/(N)^{1/2}$ equal to S_c, where S_c refers to the standard deviation of replicate determinations at a fixed concentration.

The theory: method detection limit depicted as an error distribution



measured, and reported with 99% confidence that the analyte concentration is greater than zero and is determined from replicate analyses of a sample of a given matrix containing analyte (14).

Single step procedure

The procedure for determining MDL is based on the analysis of seven samples of the matrix containing analyte. If the MDL is to be determined in reagent (blank) water, a laboratory standard of the analyte in reagent water is prepared at a concentration at least equal to or in the same concentration range as the estimated MDL. We recommend that the analyte be added to the water to give a final concentration between one and five times the estimated MDL. When the MDL is to be determined in a sample matrix other than reagent water, analysis of the sample background is required..

If the measured level of analyte is less than the estimated MDL, the analyte is spiked into the matrix to bring the level of analyte to a concentration between one and five times the estimated MDL. Should the measured level of analyte be greater than five times the estimated MDL, two options exist:

- the analyst is required to obtain another sample of the same matrix with a lower level of analyte present
- the sample may be used as is for the MDL determination if the analyte level does not exceed 10 times the MDL of the analyte in reagent water.

The error variance of the analytical method changes as the analyte concentration increases above MDL. Hence, MDL values determined in a matrix containing a high analyte concentration may not truly reflect method error variance at lower analyte concentrations.

A minimum of seven aliquots of matrix are processed through the entire analytical method and the MDL is calculated. All concentration calculations are made according to the defined method, with final results expressed in the method reporting units. If a blank measurement is required to calculate the measured level of analyte, the analyst must obtain a separate blank measurement for each sample aliquot analyzed. The average blank measurement is subtracted from the respective sample measurements.

It may be economically and technically desirable to evaluate the estimated MDL before proceeding with the analysis of the seven aliquots. This will prevent repeating the entire procedure and ensure that the MDL determination is being conducted at the correct concentration. It is quite possible that an incorrect MDL could be calculated from data obtained at many times the actual MDL even though the level of analyte would be less than five times the calculated method detection limit.

To ensure that the estimate of the method detection limit is a good estimate, the analyst must determine that a lower concentration of analyte will not result in a significantly lower calculated MDL. We recommend initial analysis of two aliquots of the sample for this purpose. Should these measurements indicate that the sample is in the desirable range for the MDL determination, five additional aliquots are processed through the MDL procedure. If the sample is not in the correct range, the MDL must be reestimated and seven new aliquots of the sample matrix processed as described.

The standard deviation of the seven replicate measurements is calculated and the MDL is computed as

$$\mathrm{MDL} = t_{(N-1,1-\alpha=.99)} \times S_c \quad (9)$$

where:

$$t_{(N-1,1-\alpha=.99)}$$

Testing the theory

This theory is tested by collecting data from a limited number of samples at a single concentration estimated to be in a sufficiently large neighborhood proximate to the MDL. The directions given to guide the analyst in estimating the MDL are the following:

- the concentration value that corresponds to an instrument signal/noise in the range of 2.5–5. If the criteria for qualitative identification of the analyte is based upon pattern recognition techniques, the least abundant signal necessary to achieve identification must be considered
- the concentration value that corresponds to three times the standard deviation of replicate instrumental measurements for the analyte in reagent water
- the concentration value that corresponds to the region of the standard curve where there is a significant change in sensitivity at low analyte concentrations, i.e., a break in the slope of the standard curve
- the concentration value that corresponds to known instrumental limitations.

The analyst's experience is not intended to supersede any of the other considerations, but it does provide for crucial input of any relevant background with which a decision can be reached if the other directions for estimation are either inoperative or do not give a clear choice for estimating the MDL.

Invoking these criteria for estimation of the MDL involves a risk such that if the initial estimates of the MDL are not proximate to the (true) MDL, the calculated MDL will be much in error. The assumptions involved in the estimation of the MDL can be tested in one of two ways:

1. The estimated MDL is equal to the calculated MDL, if the 95% confidence interval of the calculated MDL contains the estimated MDL value.
2. If the condition set forth in item 1 is not satisfied, then an iterative procedure, where the most recent calculated MDL value is used as the next estimated MDL, must be used until the variances of successive iterations do not differ using the F test.

Clearly, the MDL is prescribed by any attending instrumental detection limits. The procedure to determine the MDL was designed to apply to a wide variety of sample matrices ranging from reagent (blank) water containing analyte to wastewater containing analyte. Thus, the MDL for an analytical procedure may vary as a function of the sample type (matrix). The developed procedure requires a complete, specific, and well-defined analytical method. All sample processing steps of the analytical method must be included in the determination of the method detection limit.

A crucial point is that the MDL for a given analyte in a given matrix does not preclude quantitation below the MDL. However, when quantitation below MDL is pursued, the confidence interval estimate of an analyte concentration below MDL will be greater than at MDL for a given confidence level and a given analytical effort. In other words, it would require a greater number of samples to analyze for an analyte concentration below MDL to achieve the same confidence limits attached to the MDL.

is the student's t value for a one-tailed test at the 99% confidence level with $N - 1$ degrees of freedom. S_c is the standard deviation of the seven replicate analyses. Confidence-interval estimates for the MDL are computed using percentiles of the chi square over degrees of freedom distribution (χ^2/df). The 95% confidence limits for the MDL are computed in Equations 10 and 11:

$$\frac{\mathrm{UCL_{MDL}}}{P_{.025}} > \mathrm{MDL} > \frac{\mathrm{LCL_{MDL}}}{P_{.975}} \quad (10)$$

where the percentile values are obtained from the χ^2/df distribution for the associated degrees of freedom ($df = 6$).

$$\mathrm{LCL_{MDL}} = 0.64\ \mathrm{MDL}$$
$$\mathrm{UCL_{MDL}} = 2.20\ \mathrm{MDL} \quad (11)$$

The confidence limit expressions reduce to Equation 11 where $\mathrm{LCL_{MDL}}$ and $\mathrm{UCL_{MDL}}$ are the lower and upper 95% confidence limits of the MDL based upon the analysis of seven aliquots.

Iterative procedure

An additional procedure is presented to test the reasonableness of the MDL estimate and subsequent MDL determinations on the same matrix. The initial calculated MDL is tested by spiking the matrix at the calculated MDL and processing the seven samples through the entire MDL procedure. At each iteration of the MDL calculation, the variance from the current MDL calculation and the variance of the preceeding MDL calculation are compared by computing the F-ratio, which is compared with the tabulated F-ratio, $F_{0.95(6,6)} = 3.05$. If the computed F-ratio is less than 3.05, then the pooled standard deviation is calculated using the standard deviation of the current MDL determination and the preceeding iteration. The MDL is then calculated in Equation 12:

$$\mathrm{MDL} = 2.681 \times S_{\mathrm{pooled}} \quad (12)$$

where:

2.681 is equal to $t_{(12,\ 1-\alpha=.99)}$
and $S_{\mathrm{pooled}} = [(S_A{}^2 + S_B{}^2)/2]^{1/2}$

The confidence levels for the MDL of the iterative procedure are computed from the percentiles of the chi squared over degrees of freedom distribution with degrees of freedom ($N = 12$) based on 14 aliquots. Two degrees of freedom are lost in the calculation of the averages of the two sets of seven aliquots.

The confidence limit expression for the MDL based on the iterative procedure reduces to

$$\mathrm{LCL_{MDL}} = 0.72\ \mathrm{MDL}$$
$$\mathrm{UCL_{MDL}} = 1.65\ \mathrm{MDL} \quad (13)$$

where $\mathrm{LCL_{MDL}}$ and $\mathrm{UCL_{MDL}}$ (13) are the lower and upper 95% confidence limits of the MDL based on the analysis of 14 aliquots.

When the analyte is present in the matrix at a relatively "high" concentration, measurement of the MDL is not meaningful. If the analyte is found at a relatively "low" level in the sample matrix, the sample at that analyte concentration may be used as the initial estimate of the MDL, and the sample aliquots processed through the MDL procedure. However, if the calculated MDL is lower than the background level of analyte present in that matrix, the iterative procedure cannot be used. Convergence of the iterative procedure will depend on the closeness of the estimated MDL, or the background level of analyte present in the matrix, to the calculated MDL.

Reporting information

The analytical method used must be specifically identified by number or title and the MDL for each analyte expressed in the appropriate method reporting units. If the analytical method permits options affecting the method detection limit, such options must be specified with the MDL value. The analyst must also report the mean analyte level and specify the matrix used with the MDL. If a laboratory standard or a sample that contained a known amount of analyte was used for this determination, the mean recovery must also be reported. If the level of analyte in the sample is below the determined MDL or does not exceed 10 times the MDL of the analyte in reagent water, no MDL value is reported.

Applications

Method detection data were collected for the organic priority pollutant methods and are displayed in Tables 1-5. Data for Method 603-acrolein and acrylonitrile are currently unavailable. The earlier estimates of detection limits cited in Reference 5 were based solely on signal-to-noise criteria.

Some of the reported MDL values in the tables are at concentrations higher than had been anticipated. Low values for MDL are closely tied to the learning curve of each method. Experience has demonstrated that the analyst who has extensive experience with a given method is more likely to generate lower MDL values than an analyst with only cursory experience with the method.

The optional iterative scheme was developed as a response to high MDL values in these tables. These larger values are attributed to a mistaken estimate of the MDL. The closeness of the initial estimate to the final calculated MDL is a critical concern in using this procedure. The tables are organized according to each method and its particular set of analytes. Background, spike level, percent recovery, and matrix types are included as specified in the reporting requirements for the MDL.

Some analytes in Tables 2 and 3 gave wastewater background levels that range from 18 to 90 000 times larger than the respective reagent water MDL value; therefore, no wastewater MDL value should be reported. However, the wastewater MDL values are included to illustrate that the MDL procedure can give meaningless values when the analyte or analyte plus interference is present at levels much larger than 10 times the MDL value in reagent water.

For these analytes, the calculated wastewater MDL values averaged 240 times larger (range 6 to 1150) than the respective reagent water MDL value. There are analytes in Table 2 that exhibited wastewater background levels that range from 0.8 to 8 times the respective MDL value in reagent water. The MDL procedure gave meaningful values for these analytes since the wastewater MDL values averaged 2 times larger (range 0.4 to 9) than the respective reagent water MDL values.

Method 602—purgeable aromatics

This is not a purge-and-trap method using packed column gas chromatography and a photoionization detector. The MDL values listed in Table 1 for the purgeable aromatics are quite reasonable for reagent water although, except for toluene, the recoveries are consistently over 100%. The MDL values calculated for the two wastewaters are derived from background analyte levels when the analyte was present in the wastewater and from spike levels when absent. Recoveries and MDL values for analytes spiked into wastewater No. 1 are reasonable but the MDL value based on the background concentration of 1,2-dichlorobenzene is not. The MDL value for 1,2-dichlorobenzene reflects a large variation in the analyte background level. However, the MDL value loses its meaning since the analyte is present

TABLE 1

Method detection limit for purgeable aromatics as analyzed by Method 602 (*22*)

	Reagent water				Wastewater No. 1[a]				Wastewater No. 2[b]		
Compound	Spike level (μg/L)	Average % recovery	MDL (μg/L)	Background	Spike level (μg/L)	Average % recovery	MDL (μg/L)	Background	Spike level (μg/L)	Average % recovery	MDL (μg/L)
Benzene	0.5	131	0.2	0.4	0.0	—	1.74	41.	0.0	—	30.0[c]
Toluene	0.5	80	0.2	3.6[c]	0.0	—	1.55	538	0.0	—	230[c]
Ethyl Benzene	0.5	120	0.2	0.0	0.5	100	0.2	70	0.0	—	34[c]
Chlorobenzene	0.5	120	0.2	0.0	0.5	60	0.2	69	0.0	—	197[c]
1,2-Dichlorobenzene	0.5	120	0.4	34[c]	0.0	—	20[c]	1.8	0.0	—	0.4[c]
1,3-Dichlorobenzene	0.5	120	0.4	0.0	0.5	80	0.3	1.6	0.0	—	1.0
1,4-Dichlorobenzene	0.5	140	0.3	0.0	0.5	40	0.4	7	0.0	—	1.7[c]

[a] Effluent from chemical intermediates manufacturer.

[b] Effluent from rubber, plasticizers and specialty chemicals manufacturing facility

[c] Background greater than 10 times calculated MDL in reagent water.

in determinable quantities. The MDL values in wastewater No. 2 are similarly inflated.

Method 605—benzidines

This is a HPLC method using reverse-phase chromatography and an electrochemical detector. The MDL value for benzidine in reagent water was determined using an electrochemical detector potential of +0.8 V vs. S.C.E., while in the two wastewaters, the MDL was determined using a potential of 0.6 V due to the presence of interfering peaks at 0.8 V. Reducing the potential gives more specificity for benzidine but also lowers the instrumental sensitivity. Dichlorobenzidine was determined at +0.8 V in all matrices. The estimated MDLs published with the earlier version of this method (*5*) have nearly been achieved. In the reagent water and wastewater No. 1, the MDLs are within a factor of two of those originally estimated, while for wastewater No. 2 they are approximately a factor of 4 higher for benzidine and a factor of 2 higher for dichlorobenzidine. Recoveries of 60–70% for benzidine and 50–70% for dichlorobenzidine were achieved, similar to those obtained in the original method development. To achieve these MDLs, it was important to eliminate all oxidizing agents from the sample matrix. Residual chlorine, which is recognized as a notorious oxidant, was decomposed by adding 35 mg/L sodium thiosulfate to each wastewater and reagent water. The reagent water was adjusted to a neutral pH prior to spiking the sample matrix with analyte.

The low recoveries at low spiking levels are probably due to oxidation during sample processing. Since such oxidation reactions are overall second order processes (first order in both oxidant and amine), low recovery of the amine can occur at low concentrations of analyte and relatively large concentration of oxidants.

Organochlorine pesticides and PCBs

Method 608 is a GC method using packed column chromatography and an electron capture detector (ECD). The MDL values of the pesticide and PCB analytes in reagent water listed are generally equal to or lower than those reported as estimates with the earlier version of this method (*5*). Heptachlor epoxide analysis exhibited anomalous behavior in reagent water. This resulted from the presence of an interfering chromatographic peak that clearly coeluted with the compound, thus requiring blank measurements. In many instances, the level of this interference did not remain constant but was variable for the aliquots of a given matrix. In this case, the blank did not necessarily represent the background concentration of the interfering species in the sample. By averaging the background, we assume that a more reliable measure of the background is obtained.

The basic approach to determining MDLs in wastewater was the same as for reagent water. However, in the presence of coëluting or interfering substances, the analyst chose to modify the MDL procedure. In some cases, when the water contained pesticide or PCB analytes, direct calculation of the standard deviation was prevented by coeluting, interfering materials. Large fluctuations in the background were observed, which attenuated the utility of the blank measurements.

Since the response of an interfering species and analyte was being measured, the variability of the response represented the total variability due to both compounds. In this case the corrected variance of the sample, calculated by subtracting the variance of the background from the variance due to the analyte plus background was used to calculate the MDL. Two analytes in wastewater No. 1, endosulfan sulfate and γ-BHC, required this treatment. In wastewater No. 2, this alternate scheme of variance calculation was used for β-BHC, δ-BHC, γ-BHC, endosulfan sulfate, aldrin, and endosulfan II. The MDLs in wastewater No. 1 are fairly consistent but considerably higher than the reagent water MDL values. The MDL values for wastewater No. 2 compare more favorably to the reagent water than do those from wastewater No. 1,

TABLE 2

Method detection limit for benzidines as analyzed by Method 605 (*24*)

	Reagent water			Wastewater No. 1[a]		Wastewater No. 2[b]	
Compound	Spike level (μg/L)	Average % recovery	MDL	Average % recovery	MDL	Average % recovery	MDL
Benzidine	0.50	62	0.08	74	0.08[c]	74	0.19
Dichlorobenzidine	0.50	80	0.13	72	0.09	59	0.22

[a] Pigment manufacturing wastewater.

[b] Aniline manufacturing wastewater.

[c] Background was 0.06 μg/L.

TABLE 5

Method detection limits for pesticides and polychlorinated biphenyls as analyzed by method 608 (*25*)

Compound	Reagent water				Wastewater No. 1[a]			Wastewater No. 2[b]		
	Spike level (ng/L)	Average % recovery	MDL (μg/L)	Background level (ng/L)	Spike level (ng/L)	Average % recovery	MDL (μg/L)	Spike level (ng/L)	Average % recovery	MDL (μg/L)
α-BHC	9.6	99	.003	260[c]	0.0	—	0.184[c]	14.0	72	0.013
β-BHC	24.0	97	.006	—	30.0	164	0.059	30.0	94	0.011
δ-BHC	19.6	91	.009	—	43.0	84	0.062	43.0	94	0.023
γ-BHC	17.2	103	.004	—	20.0	320	0.283	20.0	101	0.007
DDD	52.0	100	.011	—	52.0	77	0.031	52.0	79	0.029
DDE	24.0	96	.004	—	20.0	129	0.038	20.0	71	0.008
DDT	70.0	99	.012	—	60.0	76	0.049	59.0	71	0.030
Endosulfan I	25.2	72	.014	—	45.0	76	0.061	73.0	99	0.056
Endosulfan II	48.0	97	.004	—	12.0	37	0.009	21.0	60	0.013
Endosulfan sulfate	272.0	81	.066	—	150.0	105	0.30	329.0	94	0.262
Heptachlor	11.6	91	.003	—	6.0	715	0.055	18.0	89	0.009
Heptachlor epoxide	18.4	153	.083	—	65.0	155	0.148	65.0	80	0.021
Aldrin	14.4	84	.004	—	20.0	140	0.055	20.0	80	0.0054
Dieldrin	30.4	100	.002	—	6.0	275	0.017	13.0	107	0.010
Endrin	43.2	101	.006	31[c]	0.0	—	0.079[c]	32.0	70	0.031
Chlordane	152.0	99	.014							
Toxaphene	156.0	99	.235							
PCB 1242	188.0	90	.065							

[a] Effluent from a pesticide manufacturing plant.
[b] Effluent from an organics and plastics manufacturing plant.
[c] Background greater than 10 times MDL in reagent water.

and reflect the lower background of electron capture-sensitive materials present in wastewater No. 2.

Polycyclic aromatic hydrocarbons

Method 610 is a reverse-phase HPLC method using UV and fluorescence detectors. From the data in Table 4, it is obvious that both recovery and precision for most of the PAHs were good, generally ±10% precision and 90–100% recovery, in all matrices. Fluoranthene was the only analyte that was significantly different. In one aliquot of reagent water, the result for fluoranthene was nearly twice the spike level. There is a possibility that this aliquot was doubly spiked; this would explain the unexpected accretion of analyte. Hence, the MDL for fluoranthene in reagent water is skewed toward a higher concentration because of the higher value of the standard deviation. Precision and recovery data for fluoranthene in the two wastewaters, one of which had a detectable background level of fluoranthene, were considerably better than in reagent water.

The fluoranthene MDL data for the wastewaters is probably a better indication of the precision of the method, providing that blank contamination is not a problem. The single reagent water aliquot giving a high result for fluoranthene was probably contaminated in some way. On occasion, fluoranthene has been observed at low concentration levels in reagent water; this points to fluoranthene as being the PAH analyte most likely to present contamination problems. This observation is more credible since fluoranthene is a highly fluorescent compound under Method 610 assay conditions, and is one of the most commonly found PAHs in environmental samples.

The MDL values obtained for the PAH analytes in these three water matrices are all equal to or lower than those estimated in the earlier version of the method (except for fluoranthene in reagent water).

2,3,7,8-Tetrachlorodibenzo-*p*-dioxin[30]

Method 613 is a gas chromatography/mass spectrometry (GC/MS) method that requires use of a capillary column, which uniquely separates 2,3,7,8-TCDD from the other 21 TCDD isomers and specifies operating the MS detector in the selected ion monitoring mode (SIM) of data acquisition. The MDL value for 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) in reagent water is 0.002 μg/L and is slightly lower than the detection limit given in the earlier version of this method (*5*). The spiking level in reagent water was 5.0 ng/L, which gave an average recovery of 95%.

This method has extremely high selectivity and sensitivity for 2,3,7,8-TCDD. Qualitative identification is based on pattern recognition using the ratio of the response for the ions at m/z 320, 322, and 257. The seven aliquots of reagent water at 5 ng/L gave an average ratio of 0.79 ± 0.04 for the ions at m/z 320 and 322.

The response for the ion at m/z 257 is approximately 30% of the response for the ion at m/z 322. Refinement of the MDL value through reiteration of the MDL procedure using a spiking level of 2 ng/L will demonstrate that the MDL is not significantly lower than 2 ng/L and will also demonstrate that qualitative identifications can be made if the 2,3,7,8-TCDD concentration is 2 ng/L.

Base/neutrals, acids & pesticides

This GC/MS method employs packed columns and requires operating the MS detector in a repetitive scan mode for data acquisition. The reagent water MDL values for 62 of the 72 analytes in Method 625 are given in Table 5. All MDL values are lower than the detection limits specified in the earlier version of this method (*5*). The table includes values for PCB-

TABLE 4

Method detection limit for polycyclic aromatic hydrocarbons as analyzed by Method 610 (*27*)

Compound	Reagent water			Wastewater No. 1 [a]		Wastewater No. 2 [b]	
	Spike level (µg/L)	Average % recovery	MDL (µg/L)	Average % recovery	MDL (µg/L)	Average % recovery	MDL (µg/L)
Napthalene	4.1	104	1.8	83	1.2	80	2.9
Acenaphthylene	8.0	95	2.3	90	2.4	88	4.0
Acenaphthene	4.9	100	1.8	88	1.5	90	1.4
Fluorene	0.80	95	0.21	93	0.22	95	0.25
Phenanthrene	2.0	95	0.64	95	0.61	90	0.79
Anthracene	2.4	96	0.66	96	0.52	92	0.99
Fluoranthene	0.084	130	0.21	107	0.02	114	0.06
Pyrene	0.86	98	0.27	103	0.13	98	0.26
Benzo(*a*)-anthracene	0.081	93	0.01	93	0.01	94	0.02
Chrysene	0.81	95	0.15	95	0.10	96	0.18
Benzo(*b*)-fluoranthene	0.64	97	0.02	98	0.01	98	0.02
Benzo(*k*)-fluoranthene	0.084	95	0.02	93	0.01	95	0.02
Benzo(*a*)-pyrene	0.81	81	0.02	98	0.01	95	0.01
Dibenzo(*a,h*)-anthracene	0.098	88	0.03	102	0.02	112	0.02
Benzo(*g,h,i*)-perylene	0.40	83	0.08	98	0.08	98	0.13
Indeno(1,2,3-*cd*)pyrene	0.15	93	0.04	93	0.03	93	0.04

[a] Refinery effluent.

[b] Coke oven effluent.

1221 and PCB-1254 that were not specified before.

During the MDL study for Method 625, concentration was done using the optional nitrogen blow-down instead of the second micro Kuderna–Danish concentration. Recoveries ranged from 28–94% for the 62 analytes studied; however, only eight analytes gave an average recovery larger than the recovery for that analyte in Methods 604 through 612. There were two instances where the calculated MDL was larger than the spike level. Nineteen values are based on the analysis of eight or 10 aliquots.

Overall, it is best to view the MDL values in Table 5 as initial values subject to refinement through iteration of the MDL procedure. Since the qualitative identification scheme for this mass spectrometer method relies on lower abundance ions with variance not reflected in the calculation of the MDL value, it is possible that qualitative verification might not be made when the analyte is present at a concentration in the neighborhood of MDL. This is another reason to pursue an iteration of the MDL procedure for Method 625.

Comparing the reagent water MDL values for the phenolic analytes common to both Methods 604 and 625 shows that only 4-nitrophenol and pentachlorophenol gave lower MDL values in Method 625.

4-Nitrophenol was spiked at 10 µg/L in the MDL study for Method 625 and at 15.4 µg/L for the Method 604 study. The corresponding spike levels for pentachlorophenol were 10 µg/L and 21 µg/L. Thus, the interaction between instrumental sensitivity and spiking level can be seen to have an effect on the calculated MDL. The remaining phenolic analytes gave MDL values for Method 625 that were between 1.5 and 11 times larger than the corresponding values in Method 604.

The reagent water MDL value for 3,3′-dichlorobenzidine in Method 625 is 250 times larger than that value in Method 605. Since the average recoveries for this analyte are approximately equal in both methods, this large difference reflects instrumental differences in both sensitivity and chromatography. As a rule, amines chromatograph much better under reverse-phase HPLC conditions than gas chromatography conditions. No MDL value for benzidine is reported with Method 625 because of losses experienced in the drying and concentration steps.

In those cases in which the phthalates were spiked at higher concentrations in the Method 625 MDL study compared to the Method 606 study, the MDL values were approximately four to seven times higher than the Method 606 MDL values. Bis(2-ethylhexyl)phthalate was spiked at nearly identical concentrations in both MDL studies and gave nearly identical MDL values. Di-*n*-octyl phthalate was spiked at a lower concentration in the Method 625 MDL study and gave a slightly lower MDL value compared to Method 606.

Method 625 and Method 606 show opposite trends in the average recovery of the phthalates. In Method 625 recovery increases with increasing retention time, but decreases with increasing retention time in Method 606. All Method 625 MDL values are close to the spiking values; therefore, iteration of the MDL procedure for the phthalates may not result in much different MDL values.

The nitroso analyte in the Method 625 MDL study exhibits an MDL value consistent with the differences in instrumental sensitivity between Method 625 and Method 607. In Method 625, the spiking level was 12 times higher than in Method 607 and the calculated MDL value was 17 times higher.

The pesticide analytes that survive the basic extraction step of Method 625 show MDL values between 27 and 1400 times higher than the corresponding values in Method 608. Heptachlor epoxide displayed the least difference and 4,4′-DDE displayed the greatest difference. The average recovery in the Method 625 MDL study is generally lower than that in Method 608; however, no recovery was greater than 100%, as was the case in Method 608. The pesticides α-BHC, γ-BHC, endosulfan I, endosulfan II, and endrin were lost during the basic extraction step. Large differences in detector sensitivity are responsible for the large differences in MDL between Method 625 and 608.

The MDL values for nitrobenzene and isophorone again show the interplay between the original estimate of MDL and the subsequent value of the calculated MDL. In Method 625, both analytes were spiked into reagent water at concentrations lower than that used in Method 609 and each gave a lower MDL value. Since there is not a great deal of difference between instrumental sensitivity in this case, it is not surprising that the lower estimate for MDL resulted in a lower calculated MDL. In contrast, the dinitrotoluene analytes gave MDL values that were 220 and 320 times larger in Method 625 compared to Method 609. This difference is attributed to the large differences between instrumental sensitivity in these two methods.

Method 625 MDL values for the first three eluting PAH analytes (naphthalene, acenaphthalene, and acenaphthylene) are very similar to the values obtained for Method 610. These three analytes are detected with a UV detector similar in instrumental sensitivity to the mass spectrometer used in Method 625. Naphthalene was the only PAH analyte that gave a lower MDL value in Method 625, but it was also the only analyte spiked at a lower concentration in Method 625 compared to 610. The 13 remaining PAH analytes gave MDL values in Method 625 that were between 3 and 780 times higher than the corresponding values in Method 610. This reflects the differences between the fluorometer and mass spectrometer in detector sensitivity. Benzo(*g*, *h*, *i*)perylene gave an MDL larger than the spike level in the Method 625 study and it was the only PAH in Method 625 that gave an average recovery higher than the corresponding recovery in Method 610.

The haloether analytes in Method 625 gave MDL values consistent with detector sensitivity and spiking level. The calculated MDL for 4-bromophenyl phenyl ether was lower than the value in Method 611, but it was also spiked at a lower level. The remaining haloether analytes gave MDL values ranging from 1.1 to 19 times larger than the corresponding values in Method 611. Clearly, there is no great difference in MDL results between these two methods. The Method 625 haloether recoveries were about half those reported in Method 611.

1,3-Dichlorobenzene gave an anomalous MDL value when compared to the other analytes in Method 625. Highly variable losses were attributed to the volatility of the analyte. The spike level was lower than that in Method 612, but in Method 625 the

TABLE 5

Method detection limits for compounds as analyzed by Method 625 in reagent water (*31*)

Compound	Spike level (μg/L)	Average % recovery	MDL (μg/L)
Acenaphthene	3.8	63	1.9
Acenaphthylene	3.8	47	3.5
Anthracene	3.8	70	1.9
Aldrin	10	72	1.9
Benzo(*a*)anthracene	25	88	7.8
Benzo(*k*)fluoranthene	3.8	80	2.5
Benzo(*a*)pyrene	3.8	73	2.5
Benzo(*g*,*h*,*i*)perylene	3.8	92	4.1
Benzyl butyl phthalate	3.8	74	2.5
Bis(2-chloroethyl) ether	13.3	43	5.7
Bis-(2-chloroethoxy) methane	13.3	45	5.3
Bis(2-ethylhexyl) phthalate	3.8	94	2.5
Bis(2-chloroisopropyl) ether	25	81	6.3
4-Bromophenyl phenyl ether	3.8	86	1.9
2-Chloronaphthalene	3.8	66	1.9
Chrysene	3.8	86	2.5
4-4′-DDD	10	80	2.8
4,4′-DDT	10	83	4.7
Dibenzo(*a*,*h*)anthracene	3.8	82	2.5
Di-*n*-butyl phthalate	3.8	85	2.5
1,3-Dichlorobenzene	3.8	60	4.4
1,4-Dichlorobenzene	13.3	40	5.0
Dieldrin	10	83	2.5
Diethyl phthalate	3.8	64	1.9
Dimethyl phthalate	3.8	49	1.6
2,6-Dinitrotoluene	3.8	64	1.9
Di-*n*-octyl phthalate	3.8	84	2.5
Fluoranthene	3.8	80	2.2
Fluorene	3.8	64	1.9
Heptachlor	10	69	1.9
Heptachlor epoxide	10	82	2.2
Hexachlorobenzene	3.8	67	1.9
Hexachlorobutadiene	3.8	58	0.9
Hexachloroethane	3.8	.60	1.6
Indeno(1,2,3-*cd*)pyrene	3.8	85	3.7
Isophorone	3.8	69	2.2
Naphthalene	3.8	70	1.6
Nitrobenzene	3.8	68	1.9
N-Nitroso-di-*n*-propylamine	25	66	8
Pyrene	3.8	79	1.9
1,2,4-Trichlorobenzene	3.8	68	1.9
Benzo(b)fluoranthene[a]	13.3	45	4.8
4-Chlorophenyl phenyl ether[a]	13.3	45	4.2
3,3′-Dichlorobenzidene[a]	33	52	16.5
2,4,-Dinitrotoluene[a]	13.3	44	5.7
PCB 1221[a]	91	77	30
PCB 1254[a]	91	80	36
Phenanthrene[a]	13.3	51	5.4
4-Chloro-3-methylphenol[a]	10	71	3.0
2,4-Dichlorophenol[a]	10	60	2.7
2,4-Dimethylphenol[a]	10	57	2.7
2,4-Dinitrophenol[a]	40	94	42
2-Methyl-4,6-dinitrophenol[a]	40	77	24
4-Nitrophenol[a]	10	52	2.4
Pentachlorophenol[a]	10	87	3.6
Phenol[a]	10	28	1.5
2,4,6-Trichlorophenol[a]	10	64	2.7
*β*BHC[b]	6	89	4.2
*δ*BHC[b]	6	56	3.1
4,4′-DDE[b]	10	69	5.8
Endosulfan sulfate[b]	7	79	5.6

[a] MDL based on 8 aliquots of reagent water.
[b] MDL based on 10 aliquots of reagent water.

calculated MDL value was larger than the spike level. Hence the results for this chlorinated hydrocarbon analyte should be regarded with caution.

Conclusions

The purpose of this procedure is to provide a MDL that is used to judge the significance of a single measurement of a future sample. The MDL procedure was formulated to accommodate application to a broad variety of physical and chemical methods. It was necessary to make the procedure device—or instrument—independent to accomplish the wide application desired.

The measurement of the MDL value, in a given matrix, is meaningless if it can be shown by analyte-specific methods that a high background is due to interference rather than the analyte in question. Standard additions in a large neighborhood proximate to the MDL on an interfering background for the purpose of determining the MDL can have value in providing an accuracy and precision statement for the analytical method at analyte levels comparable to the interference concentration in that specific matrix.

The iterative procedure is presented only as a means to overcome mistaken estimates for the MDL. When the analyte is present in the matrix due solely to standard additions and the estimated MDL was found to be outside the 95% confidence interval of the calculated MDL, only one or two iterations should be necessary to identify the MDL with sufficient accuracy. However, only a full regression treatment would provide a more complete description. When economically feasible, the full regression treatment should be used.

If the relative standard deviation of the seven replicates is in the range of 20.5–70.1%, then the estimated MDL will be within the 95% confidence interval of the calculated MDL. This is sufficient statistical evidence to stop the iterative MDL procedure. Should the relative standard deviation fall outside this range, the results are suspect. Experience has shown that when the relative standard deviation is at or near 10%, the calculated MDL values can be below instrumental detection limits.

We can look forward to continued lowering of such performance characteristics as established analytical procedures are adjusted to accommodate future advances in analytical technology. This will serve to push the MDL to lower values than those previously assigned.

Acknowledgments

We wish to recognize the analysts of Battelle Columbus Laboratories, IT Enviroscience, Monsanto Research Corporation-Dayton Laboratory, and Southwest Research Institute, who generated the MDL data for Methods 601 through 613. An EMSL team of analysts are recognized as the source of the MDL data for Methods 624 and 625. A number of our EMSL coworkers have personally contributed to the concept of MDL in this regard. We wish to acknowledge the constructive input of Thomas Bellar, Paul Britton, Seymour Gold, James Lichtenberg, and James Longbottom.

Before publication this article was commented on for technical accuracy by Dr. eorge W. Barton, Jr., Lawrence Livermore Laboratory, University of California, .O. Box 808, Livermore, Calif. 94550, nd Dr. Ervin J. Fenyves, the University of exas at Dallas, P.O. Box 688, Richardson, ex. 75080

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Supplementary Material Available: *Tables 6-14 contain additional Method Detection Limits (MDLs) for the analyses of trace organics in wastewater. Table 6—volatile compounds by Method 601. Table 7—phenols by Method 604 using flame ionization detection. Table 8—pentafluorobenzyl derivatives of phenols by Method 604 using electron capture detection. Table 9—phthalates by Method 606. Table 10—nitrosamines by Method 607. Table 11—nitroaromatics and isophorone by Method 609. Table 12—haloethers by Method 611. Table 13—chlorinated hydrocarbons by Method 612. Table 14—volatile compounds by Method 624 using GC/MS. Photocopies of the supplementary material from this paper or microfiche (105 × 148 mm, 24 × reduction, negatives) may be obtained from Business Operations, Books and Journals Division, American Chemical Society, 1155 16th St., N.W., Washington, D.C. 20036. Full bibliographic citation (journal, title of article, author) and prepayment, check or money order for $13 for photocopy ($14.50 foreign) or $4 for microfiche ($5 foreign), are required.*

*USGPO: 1982 — 559-092/3394

1/21/81

Definition and Procedure for the Determination of the Method Detection Limit

Revision 1.11

by

EMSL - CI

Environmental Protection Agency
Office of Research and Development
Environmental Monitoring and Support Laboratory
Cincinnati, Ohio 45268

Definition

The method detection limit (MDL) is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and determined from analysis of a sample in a given matrix containing analyte.

Scope and Application

This procedure is designed for applicability to a wide variety of sample types ranging from reagent (blank) water containing analyte to wastewater containing analyte. The MDL for an analytical procedure may vary as a function of sample type. The procedure requires a complete, specific and well defined analytical method. It is essential that all sample processing steps of the analytical method be included in the determination of the method detection limit.

The MDL obtained by this procedure is used to judge the significance of a single measurement of a future sample.

The MDL procedure was designed for applicability to a broad variety of physical and chemical methods. To accomplish this, the procedure was made devise- or instrument-independent.

Procedure

1. Make an estimate of the detection limit using one of the following:

    (a) The concentration value that corresponds to an instrument signal/noise in the range of 2.5 to 5.

    (b) Three times the standard deviation of replicate instrumental measurements of the reagent water.

(c) The area of the standard curve where there is a significant change in sensitivity, i.e., a break in the slope of the standard curve.

(d) Instrumental limitations.

It is recognized that the experience of the analyst is important to this process. However, the analyst must include the above considerations in the estimate of the detection limit.

2. Prepare reagent (blank) water that is as free of analyte as possible. Reagent or interference free water is defined as a water sample in which analyte and interferent concentrations are not detected at the method detection limit of each analyte of interest. Interferences are defined as systematic errors in the measured analytical signal of an established procedure caused by the presence of interfering species (interferent). The interferent concentration is presupposed to be normally distributed in representative samples of a given matrix.

3. (a) If the MDL is to be determined in reagent (blank) water, prepare a laboratory standard (analyte in reagent water) as a concentration which is at least equal to or in the same concentration range as the estimated method detection limit. (Recommend between 1 and 5 times the estimated method detection limit.) Proceed to Step 4.

   (b) If the MDL is to be determined in another sample matrix, analyze the sample. If the measured level of the analyte is in the recommended range of one to five times the estimated detection limit, proceed to Step 4.

If the measured level of analyte is less than the estimated detection limit, add a known amount of analyte to bring the level of analyte between one and five times the estimated detection limit.

If the measured level of analyte is greater than five times the estimated detection limit, there are two options.

(1) Obtain another sample of lower level of analyte in same matrix if possible.

(2) The sample may be used as is for determining the method detection limit if the analyte level does not exceed 10 times the MDL of the analyte in reagent water. The variance of the analytical method changes as the analyte concentration increases from the MDL, hence the MDL determined under these circumstances may not truly reflect method variance at lower analyte concentrations.

4. (a) Take a minimum of seven aliquots of the sample to be used to calculate the method detection limit and process each through the entire analytical method. Make all computations according to the defined method with final results in the method reporting units. If a blank measurement is required to calculate the measured level of analyte, obtain a separate blank measurement for each sample aliquot analyzed. The average blank measurement is subtracted from the respective sample measurements.

(b) It may be economically and technically desirable to evaluate the estimated method detection limit before proceeding with 4a. This will: (1) prevent repeating this entire procedure when the costs of analyses are high and (2) insure that the procedure is being conducted at the correct concentration. It is quite possible that an incorrect MDL could be calculated from data obtained at many times the real MDL and the level of analyte would be less than five times the calculated method detection limit. To insure that the estimate of the method detection limit is a good estimate, it is necessary to determine that a lower concentration of analyte will not result in a significantly lower method detection limit. Take two aliquots of the sample to be used to calculate the method detection limit and process each through the entire method, including blank measurements as described above in 4a. Evaluate these data:

(1) If these measurements indicate the sample is in desirable range for determination of the MDL, take five additional aliquots and proceed. Use all seven measurements for calculation of the MDL.

(2) If these measurements indicate the sample is not in correct range, reestimate the MDL, obtain new sample as in 3 and repeat either 4a or 4b.

5. Calculate the variance (S^2) and standard deviation (S) of the replicate measurements, as follows:

$$S^2 = \frac{1}{n-1}\left[\left(\sum_{i=1}^{n} x_i^2\right) - \left(\sum_{i=1}^{n} x_i\right)^2 \Big/ n\right]$$

$S = (S^2)^{1/2}$

where the x_i, $i=1$ to n are the analytical results in the final method reporting units obtained from the n sample aliquots and refers to the sum of the X values from i=1 to n.

6. a.) Compute the MDL as follows:

$$\text{MDL} = t_{(n-1,.99)}\ (S)$$

where:

MDL = the method detection limit

$t_{(n-1,.99)}$ = the students' t value appropriate for a 99% confidence level and a standard deviation estimate with n-1 degrees of freedom. See Table.

S = Standard deviation of the replicate analyses.

b.) The 95% confidence interval estimates for the MDL derived in 6a are computed according to the following equations derived from percentiles of the chi square over degrees of freedom distribution (X^2/df).

$$\text{LCL} = 0.69\ \text{MDL}$$
$$\text{UCL} = 1.92\ \text{MDL}$$

where LCL and UCL are the lower and upper 95% confidence limits respectively based on seven aliquots.

7. Optional iterative procedure to verify the reasonableness of the estimate of the MDL and subsequent MDL determinations.

a.) If this is the initial attempt to compute MDL based on the estimate of MDL formulated in Step 1, take the MDL as calculated in Step 6, spike in the matrix at the calculated MDL and proceed through the procedure starting with Step 4.

b.) If this is the second or later iteration of the MDL calculation, use S^2 from the current MDL calculation and S^2 from the previous MDL calculation to compute the F-ration. The F-ratio is formed by substituting the largest $S^2$of the two into the numerator S and the other into the denominator S. The computed F-ratio is then compared with the F-ratio found in the table which is 3.05 as follows:

$$\text{if} \quad \frac{S^2_A}{S^2_B} < 3.05,$$

then compute the pooled standard deviaiton by the following equation:

$$S_{\text{pooled}} = \left[\frac{6S^2_A + 6S^2_B}{12} \right]^{1/2}$$

$$\text{if} \quad \frac{S^2_A}{S^2_B} > 3.05,$$

respike at the last calculated MDL and process the samples through the procedure starting with Step 4.

c.) Use the S_{pooled} as calculated in 7b to compute the final MDL according to the following equation:

$$MDL = 2.681 (S_{pooled})$$

where 2.681 is equal to $t_{(12, = .99)}$.

d.) The 95% confidence limits for MDL derived in 7c are computed according to the following equations derived from percentiles of the chi squared over degrees of freedom distribution.

LCL = 0.72 MDL
UCL = 1.65 MDL

where LCL and UCL are the lower and upper 95% confidence limits respectively based on 14 aliquots.

Table of Students' t Values at the 99 Percent Confidence Level

Number of	Degrees of Freedom	$t_{(n-1,.99)}$
7	6	3.143
8	7	2.998
9	8	2.896
10	9	2.821
11	10	2.764
16	15	2.602
21	20	2.528
26	25	2.485
31	30	2.457
61	60	2.390
00	00	2.326

Reporting

The analytical method used must be specifically identified by number of title and the MDL for each analyte expressed in the appropriate method reporting units. If the analytical method permits options which affect the method detection limit, these conditions must be specified with the MDL value. The sample matrix used to determine the MDL must also be identified with the MDL value. Report the mean analyte level with the MDL. If a laboratory standard or a sample that contained a known amount analyte was used for this determination, also report the mean recovery.

If the level of analyte in the sample was below the determined MDL or does not exceed 10 times the MDL of the analyte in reagent water, do not report a value for the MDL.

REFERENCE 4

FIELD RESULTS - DATA SHEETS

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
ENVIRONMENTAL MONITORING AND SUPPORT LABORATORY
CINCINNATI, OHIO 45268

DATE: July 21, 1982

SUBJECT: Settleable Solids

FROM: Gerald D. McKee, Chief
Inorganic Analyses Section
Physical and Chemical Methods Branch

TO: William Telliard, Chief
Energy and Mining Branch
Effluent Guidelines Division
U.S. Environmental Protection Agency (WH-552)
Washington, D.C. 20460

Enclosed are the Method Detection Limits (MDL) calculated from the settleable solids field data.

All of the observers' data were included in the calculations for each sample because there was only one aliquoting into each Imhoff cone. The calculated data are in Table 1.

Two general observations were made in regard to differences between the field data and the laboratory data:

1) Higher data values were obtained in the field than in the laboratory with exception of one sample (108).
2) The MDLs are higher for the field data, probably due to two reasons, the mean values are higher and the field data were reported to only one significant figure (one exception).

Enclosure (1):
As stated

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TABLE 1

FIELD DATA

Sample No.	Source	ml/l/hr Mean	 Standard Deviation	 MDL
82-101	Mine Pond No. 4	0.58	0.15	0.40
82-102	Mine Pond No. 8	0.36	0.081	0.20
82-103	Mine Pond No. 7	0.28	0.08	0.21
82-104	Mine Pond No. 6	0.82	0.11	0.30
82-105	Mine Pond No. 5	0.65	0.09	0.25
82-106	Mine Pond No. 2	0.36	0.043	0.11
82-107	Mine Pond No. 1	0.76	0.09	0.23
82-108	Mine Pond No. 3	0.094	0.015	0.04

Date: 5-18-82

SETTLEABLE SOLIDS TESTING

DATA SHEET

82-107

Mine Pond No. 1

Sampling Crew: W. Telliard - EPA-EGD

H. Kohlmann - Hydrotechnic

Pond Influent - Settleable Solids (ml/1) 15.0 pH 8.2

Pond Effluent - Settleable Solids (ml/1) 0.0 pH 8.0

Determination of Dilution, if required

Based on 8-liter batch, and 0,5 ml/1 range required,

x = vol. of infl. req'd; C_1 = ml/1 settleable solids in influent
y = vol. of effl. req'd; C_2 = ml/1 settleable solids in effluent
$C_1x + C_2y = 4{,}000$ ml $x + y = 8{,}000$ ml
x = 1,068 ml y = 6,932 ml

Settleable Solids Test Results (ml/1) - pH 8.0

Imhoff Cone # / Observer	1	2	3	4	5	6	7
Mine Rep.	0.8	0.7	0.9	0.7	0.9	0.8	0.6
EPA Rep.	0.7	0.8	0.8	0.7	0.7	0.7	0.7
EPA Contractor	0.65	0.85	0.80	0.90	0.90	0.75	0.7

Date: 5-19-82

SETTLEABLE SOLIDS TESTING

DATA SHEET

82-106

Mine Pond No. 2

Sampling Crew: W. Telliard - EPA-EGD
H. Kohlmann - Hydrotechnic

Pond Influent - Settleable Solids (ml/l) 24 pH 7

Pond Effluent - Settleable Solids (ml/l) 0 pH 7

Determination of Dilution, if required

Based on 8-liter batch, and 0,5 ml/l range required,

x = vol. of infl. req'd; C_1 = ml/l settleable solids in influent
y = vol. of effl. req'd; C_2 = ml/l settleable solids in effluent
$C_1x + C_2y = 4{,}000$ ml $x + y = 8{,}000$ ml

x = 667 ml y = 7333 ml

Settleable Solids Test Results (ml/l) - pH 7

Imhoff Cone # / Observer	1	2	3	4	5	6	7
Mine Rep.	0.45	0.40	0.40	0.35	0.40	0.35	0.4
EPA Rep.	0.30	0.30	0.35	0.35	0.35	0.30	0.30
EPA Contractor	0.40	0.40	0.35	0.35	0.30	0.35	0.35

Date: 5-20-82

SETTLEABLE SOLIDS TESTING

DATA SHEET

82-108

Sampling Crew: W. Telliard - EPA-EGD

H. Kohlmann - Hydrotechnic

Mine Pond No. 3

Pond Influent - Settleable Solids (ml/l) 5 pH 8

Pond Effluent - Settleable Solids (ml/l) 0 pH 7

Determination of Dilution, if required

Based on 8-liter batch, and 0,5 ml/l range required,

x = vol. of infl. req'd; C_1 = ml/l settleable solids in influent

y = vol. of effl. req'd; C_2 = ml/l settleable solids in effluent

$C_1x + C_2y = 4{,}000$ ml $x + y = 8{,}000$ ml

x = 3,200 ml y = 4,800 ml

Settleable Solids Test Results (ml/l) - pH 7

Imhoff Cone # / Observer	1	2	3	4	5	6	7
Mine Rep.	0.13	0.11	0.1	0.1	0.13	0.1	0.09
EPA Rep.	0.1	0.09	0.09	0.09	0.08	0.08	0.07
EPA Contractor	0.1	0.09	0.09	0.09	0.09	0.09	0.07

Date: 5-11-82

SETTLEABLE SOLIDS TESTING

DATA SHEET

82-101

Mine Pond No. 4

Sampling Crew: D. Ruddy - EPA-EGD
D. Ruggiero - Hydrotechnic

Pond Influent - Settleable Solids (ml/l) Non-Det. pH 7.0

Pond Effluent - Settleable Solids (ml/l) Non-Det. pH 7.0

Upper Wadge Pond - Influent SS (ml/l) 1.2 ml/l 7.0

Determination of Dilution, if required

Based on 8-liter batch, and 0,5 ml/l range required,

x = vol. of infl. req'd; C_1 = ml/l settleable solids in influent

y = vol. of effl. req'd; C_2 = ml/l settleable solids in effluent

$C_1x + C_2y = 4{,}000$ ml $x + y = 8{,}000$ ml

x = 4,666 ml y = 3,334 ml

Settleable Solids Test Results (ml/l) - pH 7.7

Imhoff Cone # / Observer	1	2	3	4	5	6	7
Mine Rep.	0.5	0.4	0.5	0.4	0.6	0.7	0.9
EPA Rep.	0.6	0.4	0.6	0.5	0.6	0.7	0.9
EPA Contractor	0.5	0.4	0.5	0.4	0.6	0.7	0.8

Date: 5-18-82

SETTLEABLE SOLIDS TESTING

DATA SHEET

82-106

Sampling Crew: D. Ruddy - EPA-EGD

D. Ruggiero - Hydrotechnic

Mine Pond No. 5

Pond Influent - Settleable Solids (ml/1) 2.0 pH 6.4

Pond Effluent - Settleable Solids (ml/1) Non-Det. pH 6.4

Determination of Dilution, if required

Based on 8-liter batch, and 0,5 ml/1 range required,

x = vol. of infl. req'd; C_1 = ml/1 settleable solids in influent
y = vol. of effl. req'd; C_2 = ml/1 settleable solids in effluent

$C_1x + C_2y$ = 4,000 ml x + y = 8,000 ml

x = 2,000 ml y = 6,000 ml

Settleable Solids Test Results (ml/1) - pH 6.4

Imhoff Cone # / Observer	1	2	3	4	5	6	7
Mine Rep.	-	-	-	-	-	-	-
EPA Rep.	0.7	0.7	0.7	0.6	0.5	0.7	0.7
EPA Contractor	0.7	0.7	0.7	0.5	0.5	0.8	0,7

Date: 5-18-82

SETTLEABLE SOLIDS TESTING

DATA SHEET

82-104

Mine Pond No. 6

Sampling Crew: D. Ruddy EPA-EGD

D. Ruggiero - Hydrotechnic

Pond Influent - Settleable Solids (ml/l) 2.0 pH 7.0

Pond Effluent - Settleable Solids (ml/l) Non-Det. pH 7.0

Determination of Dilution, if required

Based on 8-liter batch, and 0,5 ml/l range required,

x = vol. of infl. req'd;
y = vol. of effl. req'd;

C_1 = ml/l settleable solids in influent
C_2 = ml/l settleable solids in effluent

$C_1x + C_2y = 4{,}000$ ml $x + y = 8{,}000$ ml

x = 2,000 ml y = 6,000 ml

Settleable Solids Test Results (ml/l) - pH 7.0

Imhoff Cone # / Observer	1	2	3	4	5	6	7
Mine Rep.	-	-	-	-	-	-	-
EPA Rep.	0.7	1.0	0.9	0.9	0.8	0.7	0.8
EPA Contractor	0.7	1.0	0.9	0.9	0.7	0.7	0.8

Date: 5-18-82

SETTLEABLE SOLIDS TESTING

DATA SHEET

82-103

Mine Pond No. 7

Sampling Crew: D. Ruddy - EPA-EGD

D. Ruggiero - Hydrotechnic

Pond Influent - Settleable Solids (ml/l) 5 pH 6.6

Pond Effluent - Settleable Solids (ml/l) Non-Det. pH 6.6

Determination of Dilution, if required

Based on 8-liter batch, and 0,5 ml/l range required,

x = vol. of infl. req'd; C_1 = ml/l settleable solids in influent

y = vol. of effl. req'd; C_2 = ml/l settleable solids in effluent

$C_1x + C_2y = 4{,}000$ ml $x + y = 8{,}000$ ml

$x =$ 1,000 ml $y =$ 7,000 ml

Settleable Solids Test Results (ml/l) - pH 6.6

Imhoff Cone # / Observer	1	2	3	4	5	6	7
Mine Rep.	-	-	-	-	-	-	-
EPA Rep.	0.2	0.3	0.4	0.2	0.2	0.3	0.2
EPA Contractor	0.3	0.3	0.4	0.3	0.2	0.4	0.2

Date: 5-20-82

SETTLEABLE SOLIDS TESTING

DATA SHEET

82-102

Mine Pond No. 8

Sampling Crew: D. Ruddy - EPA-EGD

D. Ruggiero - Hydrotechnic

Pond Influent - Settleable Solids (ml/l) ~ 0.3 pH 8.1-8.2

Pond Effluent - Settleable Solids (ml/l) Non-Det. pH 7.6-7.7

Determination of Dilution, if required

Based on 8-liter batch, and 0,5 ml/l range required,

x = vol. of infl. req'd; C_1 = ml/l settleable solids in influent
y = vol. of effl. req'd; C_2 = ml/l settleable solids in effluent
$C_1x + C_2y = 4{,}000$ ml $x + y = 8{,}000$ ml

x = 7,000 ml y = 1,000 ml

Settleable Solids Test Results (ml/l) - pH 8.1-8.2

Imhoff Cone # Observer	1	2	3	4	5	6	7
Mine Rep.	0.3	0.3	0.3	0.4	0.3	0.3	0.5
EPA Rep.	0.3	0.4	0.3	0.4	0.3	0.3	0.5
EPA Contractor	0.3	0.4	0.3	0.5	0.3	0.3	0.5

REFERENCE 5

LABORATORY RESULTS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT
ENVIRONMENTAL MONITORING AND SUPPORT LABORATORY
CINCINNATI, OHIO 45268

DATE: June 15, 1982

SUBJECT: Settleable Solids

FROM: Gerald D. McKee, Chief
Inorganic Analyses Section
Physical and Chemical Methods Branch

TO: William Telliard, Chief
Energy and Mining Branch
Effluent Guidelines Division
U.S. Environmental Protection Agency (WH 552)
Washington, DC 20460

Enclosed are the Settleable Solids data for the eight samples we received from various mining operations. As decided in our discussion of April 22, 1982, we determined the Method Detection Limit (MDL) on each of the samples and the variability (standard deviation) of data on samples with a concentration of about 0.5 ml/l/hr Settleable Solids.

The "Method Detection Limit" is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and determined from analysis of a sample in a given matrix containing analyte. Two papers describing this method are attached. The variability of each sample is reported as the standard deviation of seven replicate measurements.

A total of 8 samples were received for analysis, 5 on 5/21/82 and 3 on 5/24/82. Samples were approximately 8 liters in volume and were contained in 2.5 gallon cubitainers. Cubitainers were placed on a large (2 ft. square) magnetic stirrer and mixed at high speed using a 4 inch Teflon coated stirbar for at least 10 minutes before aliquoting. Seven aliquots were obtained using a glass delivery tube (inserted about mid level into the sample) and compressed air to transfer the 1 liter sample directly into the plastic Imhoff cones.

The procedure used for this analysis (EPA Method 160.5) is found in "Standard Methods for the Examination of Water and Wastewater," 14th Edition, Page 95, Method 208F, Procedure 3A (1975).

To level the settled material as much as possible, the individual Imhoff cones were tapped with a wooden rod and/or the liquid was gently swirled with a glass stirring rod before reading. This leveling seemed to have no adverse effect on the solids reading.

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Data from one sample (82-104) were discarded because they were obviously not random. The first aliquot taken was the highest in concentration and each subsequent sample was lower with a range of 0.80 ml/l/hr (first) to 0.40 ml/l/hr (last). Analysis of this sample was repeated and these data are included.

The calculated data are in Table 1. Our conclusions are:

1) The calculated MDL for Settleable Solids of samples used for this investigation was 0.12 ml/l/hr. Since the Imhoff cone has divisions of only 0.1 ml, practically this MDL is 0.2 ml/l/hr.

2) The standard deviation of the six samples near 0.5 ml/l/hr (x = 0.45 ml/l/hr), excluding samples 82-102 and 82-103, is 0.043 ml/l/hr.

Enclosures:
As stated

Table 1

Sample No.	Source	ml/l/hr Mean	 Standard Deviation	 MDL
82-101	Mine Pond No. 4	0.58	0.048	0.15
82-102	Mine Pond No. 8	0.14	0.016	0.050
82-103	Mine Pond No. 7	0.12	0.018	0.057
82-104	Mine Pond No. 6	0.43	0.043	0.14
82-105	Mine Pond No. 5	0.45	0.041	0.13
82-106	Mine Pond No. 2	0.32	0.046	0.14
82-107	Mine Pond No. 1	0.37	0.038	0.12
82-108	Mine Pond No. 3	0.55	0.041	0.13

82-101 Mind Pond No. 4
Date 5-17-82, Received 5-21-982, Analyzed 5-26-82
Lt. Brown Color, Some Silt and Sticks, pH 8.3

Aliquot	ml/l/hr	
1	0.58	
2	0.60	
3	0.55	
4	0.65	
5	0.60	
6	0.50	
7	0.55	(0.45 in 820 ml)
Mean	0.58	
Std. Dev.	0.048	
MDL	0.15	

82-102 Mine Pond No. 8
Date 5-20-82. Received 5-21-82, Analyzed 5-26-82
Light Brown Color, Some Fines, pH 7.9

Aliquot	ml/l/hr
1	0.12
2	0.15
3	0.15
4	0.15
5	0.12
6	0.15
7	0.12
Mean	0.14
Std. Dev.	0.016
MDL	0.050

82-103 Mine Pond No. 7
Date 5-18-82, Received 5-12-83, Analyzed 5-27-82
Light Brown Color, Few Fines, pH 7.9

Aliquot	ml/l/hr
1	0.15
2	0.12
3	0.10
4	0.10
5	0.12
6	0.12
7	0.10
Mean	0.12
Std. Dev.	0.018
MDL	0.057

82-104 Mine Pond No. 6
Date 5-18-82, Received 5-21-82, Analyzed 6-4-82
Light Brown Color, Some Fines, pH 8.2

Aliquot	ml/l/hr
1	0.50
2	0.45
3	0.48
4	0.40
5	0.40
6	0.40
7	0.40
Mean	0.43
Std. Dev.	0.043
MDL	0.14

82-105 Mine Pond No. 5
Date 5-18-82, Received 5-21-82, Analyzed 5-27-82
Light Brown Color, Some Fines, pH 8.0

Aliquot	ml/l/hr
1	0.50
2	0.50
3	0.45
4	0.45
5	0.40
6	0.45
7	0.40
Mean	0.45
Std. Dev.	0.041
MDL	0.13

82-105 Mine Pond No. 5 Duplicate
Analyzed 6-4-82

Aliquot	ml/l/hr
1	0.45
2	0.40
3	0.40
4	0.40
5	0.42
6	0.42
7	0.45
Mean	0.42
Std. Dev.	0.022
MDL	0.070

82-106 Mind Pond No. 2
Date 5-19-82, Received 5-24-82, Analyzed 5-28-82
Light Brown Color, Some Fines, pH 7.9

Aliquot	ml/l/hr
1	0.38
2	0.35
3	0.35
4	0.30
5	0.30
6	0.25
7	0.28
Mean	0.32
Std. Dev.	0.046
MDL	0.14

82-107 Mine Pond No. 1
Date 5-18-82, Received 5-24-82, Analyzed 5-28-82
Light Brown Color, Some Fines, pH 8.2

Aliquot	ml/l/hr
1	0.40
2	0.40
3	0.40
4	0.38
5	0.30
6	0.35
7	0.38
Mean	0.37
Std. Dev.	0.038
MDL	0.12

82-107D Mind Pond No. 1
Duplicate, Analyzed 6-4-82

Aliquot	ml/l/hr
1	0.50
2	0.55
3	0.40
4	0.50
5	0.40
6	0.50
7	0.40
Mean	0.46
Std. Dev.	0.063
MDL	0.20

82-108 Mine Pond No. 3
Date 5-20-82, Received 5-24-82, Analyzed 6-2-82
Yellow Color, Heavy Flock, pH 7.9

Aliquot	ml/l/hr
1	0.50
2	0.55
3	0.60
4	0.60
5	0.50
6	0.55
7	0.55
Mean	0.55
Std. Dev.	0.041
MDL	0.13

APPENDIX C

INVESTIGATION OF POST-MINING DISCHARGES AFTER SMCRA BOND RELEASE

INVESTIGATION OF POST-MINING DISCHARGES AFTER SMCRA BOND RELEASE

SEPTEMBER 1982

Prepared by:

OFFICE OF ANALYSIS AND EVALUATION
OFFICE OF WATER REGULATIONS AND STANDARDS
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

As stated in the Preamble of the proposed Coal Mining Point Source Regulations (46 FR 3146 January 13, 1981), a data collection effort was initiated to provide the Agency with a basis for assessing the appropriateness and feasiblity of establishing national regulations applicable after SMCRA Bond Release. The objective of this effort was to assess the possibility and severity of pollution discharges at coal mines after SMCRA Bond Release, and to address the cost-effectiveness and economic impacts of setting effluent limitations after release of bond.

The Agency recognized that the minimum liability period for reclamation at underground mines that closed under OSM Regulations (44 FR 15336 March 13, 1979) had not expired and at most was only three years old. However, the Agency hoped that the information collected in the survey, combined with records and documents submitted by interested parties during the public comment period, would provide a suitable data base to project the possibility and extent of post-bond release pollution and the cost-effectiveness of extending the period of liability after a reclamation bond was released by OSM.

. A preliminary telephone survey was conducted during October and November 1980 to establish the best sources of data in the regulatory community. The responses yielded very limited information from eight states (Table 1) and little encouragement of data being available in the next few years. A literature search was also conducted at that time, which produced six reports relevant to the survey. Only one of the six reports proved to be of direct interest. The report is a study of the long-term environmental effectiveness of close down procedures at eastern underground coal mines and was prepared in August 1977 for EPA's IERL, Cincinnati. The study found that from the 200 locations identified as closed or abandoned coal mines, only 86 provided sufficient data for inclusion in the study. The study's conclusions are specified as being general and of a preliminary nature due to the extreme variability of the available data, both historical and analytical. The two conclusions of interest are: 1) that the sealing efforts with longer monitoring records covering both the pre and post closure periods were sponsored by State or Federal agencies; and 2) that based on these records the overall effect of the studied closures on water quality is beneficial. However, the effectiveness is determined predominately by the physical characteristics of the landscape and the type of mining operation instead of the sealing technology.

The questionaire portion of the survey was deferred until a sufficient number of coal mines could be identified as being relevant to the survey. Although both pro and con comments were received on post-bond release regulations during the proposed regulation's comment period, no records or documents were submitted to substantiate either position and no mines were identified for additional evaluation. Therefore, a final survey review was initiated to examine all the previous data collected and attempt to augment it with any information currently available from Federal, States, and public sources. Discussions with OSM have revealed that the Abandoned Mine Lands Program had completed one underground mine reclamation project to date, while the Federal Reclamation Program has about 200 underground mine projects (number of mines unknown) completed or under contract since FY79. Although none of these mines are known to have developed a failure (i.e., a new discharge point or an unacceptable discharge quality), none have been closed longer than the normal bonding period of five years (10 years west of the 100th meridan). The Pennsylvania Department of Environmental Resources attempted to compile a similar list of closed mines from permits issued between 1965 and 1975 to estimate the number of closed and abandoned mine inspections needed. An estimate of 1,000 closed mines was made with no estimate available on the number closed under SMCRA or state reclamation regulations, or the number causing water quality problems. The use of comprehensive field inspection to determine the status of closed or abandoned mines has not been attempted by any state or federal agencies due to the high cost, lack of trained personnel, and the uncertainty of the results. The failure of a mine seal could produce new discharge points at rock fractures, mine vents, air ducts, or even ground seeps anywhere in the vicinity of the mine site. Adverse changes in water quality could occur in normal runoff waters, new discharge points, or underground streams. The ability of a field inspection to determine the occurrence, cause, and source of any of the above events is directly related to the physical characteristics of the mine and its location. The State of Pennsylvania has required that a water-tight seal be used when closing a coal mine since 1965. In the period from 1975 to 1980, 30 small coal mines were closed by the State (20 of these are included in the report discussed previously) and 15 were closed by the mine operators. The available background, correspondence, and water quality data on six Pennsylvania closed mines currently causing water quality problems were reviewed for use as a representative sampling. This approach was rejected due to the large variability in both the mine and sealing technology parameters (when sufficient data was available to make such determinations).

Finally, another literature search was conducted in July 1982 for case studies or technology demonstrations of closed mines. Only three additional references were found potentially useful from the 397 references reviewed. The first reference is a case study on sealing an underground deep mine in Pennsylvania in compliance with the states sealing regulations. The second reference is a case study on methods used to seal a closed mine with a continuous discharge in Japan. The final reference is an evaluation of water pollution prevention and control from inactive and abandoned underground mines. It surveys mining, sealing, and treatment methods developed largely in eastern U.S. coal fields. Although useful, these three reports did not contribute significant new data.

In summary, the Agency has been able to develop estimates of the number of active, closed, and abandoned coal mines but has not been able to determine the number of closed coal mines sealed or reclaimed under SMCRA.

Also, the Agency has not been able to determine the number of closed coal mines that are the source of water quality problems after being sealed or reclaimed in compliance with SMCRA or equivalent state regulations. Based on the results of this data collection effort, it is felt that there is insufficient data available to support the development of national regulations on post-bond release. Therefore, the basis for a nationally applicable regulation for discharges after bond release does not currently exist, and any point source discharge after bond release that might occur can be addressed through the NPDES permit system.

References

(1) Telephone Survey Report
(2) Hydrotechnic Trip Report
(3) Results of 1980 Literature Search
(4) Final Survey Review Telephone Memos
(5) File Histories of six closed PA coal mines
(6) 1982 Literature Search Report

Table 1

Identification of Data From State Agencies

Pennsylvania - Limited data on 45 mines most of which is already summarized in EPA Report "Long-Term Environmental Effectiveness of Close Down Procedures - Eastern Underground Coal Mines."

Tennessee - Limited data on a few mines sealed with impervious clay or backfilled spoils.

Illinois - Data on only a few mines.

Maryland - Water Quality data on streams, not on specific mines.

Virginia - No data available.

Alabama - Three mines backfilled with spoil material.

Kentucky - Little useful data on sealing effectiveness.

West Virginia - Some data available from a demonstration project.

REFERENCE 1

TELEPHONE SURVEY REPORT

Versar inc.

MEMORANDUM

TO: Bill Kaschak cc: B. Maestri
P. Abell

FROM: Greg Schweer GS

DATE: October 24, 1980

SUBJECT: Type and Availability of Data Concerning the Long-Term Effectiveness of Underground Coal Mine Sealing Procedures 569TM-60

A telephone survey was conducted on October 21, 22, and 23, 1980, by Versar personnel to determine the type and availability of monitoring data and any other relevant data that will enable MDSD to assess the long-term effectiveness of underground coal mine sealing procedures. The scope of this survey was limited due to OMB restraints on the number of non-federal contacts allowed for survey purposes. State mining and/or environmental officials in five coal producing states (Pennsylvania, Tennessee, Maryland, Alabama, and Virginia) as well as EPA personnel in three regions (3,4, and 5) and one consulting firm (Hydrotechnics Corp) were contacted during the course of this survey. The results of the limited number of interviews conducted indicate that, with the exception of the State of Pennsylvania and the data gathered for the HRB-Singer Study, little pertinent data are available. The available data are summarized below.

- Pennsylvania - Limited seal effectiveness data available on approximately thirty abandoned mines sealed by the state and approximately fifteen mines sealed by coal companies in the past fifteen years. Water quality data available for some mines particularly in Maraine State Park.

- Tennessee - Limited seal effectiveness data available on several mines sealed with impervious clay or backfilled spoils.

- Illinois - Some mines have been reported to have been sealed but more in depth contacts are required.

- Maryland - Good water quality data available on a recently sealed mine. Locations of some old sealed mines can also be identified.

- Alabama - Limited data available on three mines backfilled with spoil material.

- Virginia - No data available.

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- West Virginia - Information available on abandoned mines sealed in the Roaring Creek - Grassy Run watersheds as part of the Federal-State Elkins Mine Drainage Pollution Control Demonstration Project. No useful contacts were established in this state.
- Kentucky - Little useful data on sealing effectiveness seem to be available.

Attached to this memorandum are photocopies of the file memos for each telephone interview conducted. Also attached are file memos from another Versar project concerning State regulations pertaining to coal mining. The latter set of memos present some general information on the extent of underground coal mining and pertinent regulations for individual states.

It is recommended that a more intensive telephone survey be conducted to further determine the type and availability of pertinent data. All the coal producing states in the Eastern United States (i.e., Illinois, Indiana, Iowa, Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia) should be investigated. At a minimum, the following officials/groups should be contacted.

- State environmental officials
- State mining officials
- State geological surveys
- U.S. Geological Survey Districts
- U.S. Bureau of Mines Districts
- University Officials
- Coal companies
- Coal industry trade associations (e.g., National Coal Association and Bituminous Coal Research)

FILE MEMO

Name	Greg Schweer	**Date**	10/23/80
Time	11:00 a.m.	**File No.**	569.1.1

Subject Coal Mine - Post Mine Drainage Control
- in State of Pennsylvania

Persons Contacted:

Name	D. Richard Thompson, Chief	**Name**	
Company	Mine Drainage Control & Reclamation Dept. Environmental Resources	**Company**	
Phone	717-783-8845	**Phone**	

Comments: Referred me to:

Richard Hoffman or Evan Schuster
Bureau of Water Quality Mgmt.
Non-Point Industrial Sources
Dept. of Environmental Resources 717-787-8184

and

Bud Frederick
Mine Area Restoration
Dept. of Environmental Resources 717-787-7668

Action Required

Pennsylvania

FILE MEMO

Name Greg Schweer
Date 10/23/80
Time 11:10 a.m.
File No. 569.1.1
Subject Coal Mines - Post Mine Drainage Control - in State of Pennsylvania

Persons Contacted:

Name Evan Schuster
Company Bureau of Water Quality Mgmt.
Phone Non-Point Industrial Sources Br.
Dept. of Environmental Resources

Name
Company
Phone

Comments:

This branch is the permit issuing section including permits for mines. "Water-tight" coal mine seals have been required since 1965 by the State of Pennsylvania. Mr. Schuster is not certain how many mines have been sealed since 1965 but a review of the files would reveal this info (15 mines have been sealed since 1976). Also, the files may contain some water quality monitoring data and any inspection reports on mine seal conditions. Due to lack of manpower and funds, the state has done little monitoring and inspection of sealed mines. Mr. Schuster was receptive to the idea of EPA extracting data from his files and for conducting a monitoring survey of the sealed mines. Mr. Schuster will assist in any way possible.

Action Required

Pennsylvania

FILE MEMO

Name Greg Schweer

Date 10/23/80

Time 1:30

File No. 569.1.1

Subject Coal Mines - Post Mine Drainage Control
- in State of Pennsylvania

Persons Contacted:

Name Bud Frederick

Company Abandoned Mine Area Restoration Division, Dept. Environmental Resources

Phone 717-787-7668

Name Dave Hogeman

Company same

Phone

Comments:

Mr. Frederick was in a day-long meeting so I spoke with his assistant, Dave Hogeman. This division is concerned with abandoned mine reclamation. Approximately 30 mines have been sealed by the state in the past 15 years. Twenty of these mines are small mines located in Moraine State Park for which there is water quality data and relatively routine inspection by the state personnel and U.S. Bureau of Mines personnel. Most of these mines were covered in the HRB-Singer study according to Hogeman. Any data in the state files can be made available to the EPA but it may require some "digging." Any request for data should be made to Bud Frederick. Hogeman's suggested that Max Macsimovic, U.S. Bureau of Mines, Pittsburgh, PA (412-675-6549) be contacted for additional information.

Action Required

Tennessee

FILE MEMO

Name Greg Schweer

Date 10/23/80

Time 3:30

File No. 569.1.1

Subject Coal Mines - Post Mine Drainage Control - in State of Tennessee

Persons Contacted:

Name	Bob McKay, Permit Office	**Name**	
Company	Tenn. State Water Quality Control Branch	**Company**	
Phone	615-741-2275	**Phone**	

Comments:

Bob McKay referred me to Gary Mabry, WQCB, Surface
Mining Office, 615-741-7883
and to Billy Tucker, Tennessee Dept. of Conservation
Surfaces Mining Office
615-741-1046

Action Required

Tennessee

FILE MEMO

Name	Greg Schweer	**Date**	10/22/80
Time	3:40	**File No.**	569.1.1

Subject Coal Mines - Post Mine Drainage Control

- in State of Tennessee

Persons Contacted:

Name	Gary Mabry, Surface Mining Off.	**Name**	
Company	Tenn. State Water Quality Control Board	**Company**	
Phone	615-741-7883	**Phone**	

Comments:
- not in office (3:40 pm 10/22)
- will call again on 10/23
- not in office (9:30 10/23)
- called at 10:30 10/23. Mabry referred me to his assistant, Cliff Bole (geologist). Mr. Bole was very helpful and interested in the survey. He said that Tennessee has limited data on the effectiveness of mine seals. In recent years, several mines have been sealed with impervious clay material or bulldozed spoils. A more elaborate seal is being required on an abandoned mine in a surface mine tract being operated by Calcan Mining Co. Mines were not required to be sealed until recently.

Action Required

He informed me of a case study of a mine near his birthplace in Western Pennsylvania. Near the town of Kettaning in Armstrong County, a mine seal broke in the summer of 1980 that had been successful for 13 years. A three-foot high flood of water gushed out of the mine and caused quite extensive damage to a trailer park downstream. He strongly recommends that I contact D. R. Thompson, Chief

Mine Drainage Control & Reclamation Division (Dept. of Env. Resources
P. O. Box 2063
Fulton Bldg., 7th Floor 717-783-8845
Harrisburg, PA 17100

FILE MEMO

Name Greg Schweer

Date 10/22/80

Time 3:20

File No. 569.1.1

Subject Coal Mines - Post Mine Drainage Control
- in State of Illinois

Persons Contacted:

Name	Al Grosbold, Director	Name	
Company	Mining Land Reclamation Council	Company	
Phone	217-782-0588	Phone	

Comments:

Called 10/22 and spoke to Mr. Grosbold's assistant and explained the nature of our request. Mr. Grosbold will return the call on 10/22 or 10/23.

Action Required

Maryland

FILE MEMO

Name Phil Abell **Date** 10/21/80

Time 3:00 **File No.** 569.1.1

Subject Data on mine sealing in State of Maryland

Persons Contacted:

Name Pat Gallagher **Name**

Company BM - Maryland **Company**

Phone 301-689-4136 **Phone**

Comments:

See attached sheet.

Action Required

Name: Pat Gallagher

State: Maryland (301)689-4136

1. Mine sealing techniques used - yes. 1 known case.
   Double - blkhead (gravel) with center concrete plug.

2. Success in preventing post-mine drainage. This seal was finished in March 80.

3. Maintenance required - No - none anticipated. Obs. well is in place to allow monitoring.

4. Failures - W.Q. data available for:

   a) post-failure Being closely monitored.
   b) pre-sealing - yes and flow

5. Failures - has re-sealing or treatment been feasible? Treatment would be feasible. Could be pumped out if needed since it is a relatively small mine.

6. Failures - any environmental damage reported? N/A

7. Is list available of all mines sealed within the past five years? N/A
   This is the only recent one. Some very old WPA seals.

This is a ≈ 10-acre mine.

Kentucky

FILE MEMO

Name Phil Abell Date 10-22-80

Time 3:20 File No. 569.1.1

Subject Mine sealing techniques and effectiveness

Persons Contacted:

Name Name

Company Kentucky Geological Survey Company

Phone (606) 258-5863 Phone

Comments:

Had no information. Referred me to:

Kentucky Department of Mines and Minerals
(606) 254-0367

Action Required

Alabama

FILE MEMO

Name Phil Abell

Date 10-22-80

Time 2:20

File No. 569.1.1

Subject Mine sealing techniques and effectiveness

Persons Contacted:

Name	Joe Meyers	Name	
Company	Alabama ?	Company	
Phone	(205) 277-3630	Phone	

Comments:

Had no information.

Referred me to Bob Weller in charge of lands reclamation

(205) 832-6753

Action Required

FILE MEMO

Name Phil Abell
Date 10-22-80
Time 2:35
File No. 569.1.1
Subject Mine sealing techniques and effectiveness.

Persons Contacted:

Name	Bob Weller	Name	
Company	Alabama Land Reclamation	Company	
Phone	(205) 832-6753	Phone	

Comments:

Have only "sealed" 3 mines. These were not really seals. Simply filled the mines with spoil material. No plug or cap.

Action Required

FILE MEMO

Name	Phil Abell	**Date**	22 October
Time	10:30	**File No.**	569.1.1

Subject Mine sealing techniques and effectiveness

Persons Contacted:

Name	Bob Dott (reached) Fred Kaurich (out sick)	**Name**	
Company	Va. Water Control Bd.	**Company**	
Phone	(703) 628-5183	**Phone**	

Comments:

Va. WCB does not monitor mines specifically. May have w.q. stations near mine, but that is incidental. Suggested I call:

Dept. of Labor and Industry
Division of Mines and Quarries
Big Stone Gap, Va.
(703) 523-0335

Mr. Wheatley will call 10-23-80.

Action Required

Virgnia

FILE MEMO

Name Phil Abell

Date 10-22-80

Time 2:00

File No. 569.1.1

Subject Mine sealing techniques and effectiveness.

Persons Contacted:

Name	Mr. Wheatley	Name	
Company	Va. Dept. of Labor & Industry Division of Mines & Quarries	Company	
Phone	(703) 523 0335	Phone	

Comments:

Mr. Wheatley was not in his office. Will return the call tomorrow (10-23-80).

1:10 p.m. 10-23-80

Mr. Wheatley called me back. He is not aware of any program in the state of Virginia. Mines must be closed to prevent entry of people. No record is kept of closures or water quality. At least not during the past 7 years since Wheatley has been with the office.

Action Required

FILE MEMO

Name Phil Abell

Date 10-22-80

Time 3:00

File No. 569.1.1

Subject Mine sealing techniques and effectiveness

Persons Contacted:

Name	Alex Dansberger	Name	
Company	Hydrotechnics Corp.	Company	
Phone	212-695-6800	Phone	

Comments:

Discussed the report prepared by Victoria Lickers. Alex said they really have very little information (as far as he knows) on the engineering aspects (type of seal, etc.). They're mainly concerned with water quality. He is going to try and come up with some good contacts in Penn. and will call me back.

10-23-80 Returned call. Recommended Giovannitti.

Action Required

FILE MEMO

Name Phil Abell

Date 10-22-80

Time 2:00

File No. 569.1.1

Subject Mine sealing techniques and effectiveness

Persons Contacted:

Name Mike Taimi

Company EPA - Atlanta

Phone 404-881-4727

Name

Company

Phone

Comments:

Mr. Taimi will return the call later today.

Action Required

West Virginia

FILE MEMO

Name Phil Abell

Date 10-22-80

Time 1:45

File No. 569.1.1

Subject Mine sealing and effectiveness.

Persons Contacted:

Name	Bob Scott	Name	
Company	W. Va. DNR	Company	
Phone	(304) 636-1767	Phone	

Comments:

Bob Scott was out, but is expected to return on Thursday 10-23-80.

Called again 10-23-80. Still not in. Secretary expects him in tomorrow.

Action Required

EPA - Atlanta

FILE MEMO

Name Phil Abell

Date 10-23-80

Time 3:15

File No. 569.1.1

Subject Mine sealing techniques and effectiveness.

Persons Contacted:

Name	Mike Taimi	Name	
Company	EPA- Atlanta	Company	
Phone	(404) 881-4727	Phone	

Comments:

In charge of NPDES permitting for mine.

Mike said most of the sealed mines he knows of also have large disturbed areas and spoil piles. The runoff from these is collected and discharged together with the drainage from the mine itself. This obviously biases the data and would mask the effectiveness of the sealing technique. He is not really aware of any data base on this subject for the Kentucky Region (his area).

Action Required

FILE MEMO

Name Greg Schweer

Date 10/22/80

Time 3:15

File No. 569.1.1

Subject Coal Mines - Post Mine Drainage Control
- in State of Illinois

Persons Contacted:

Name	Bob Gates	Name	
Company	EPA, Field Inspector	Company	
Phone	618-997-4371	Phone	

Comments:

Does not have any pertinent data but can identify mines that have been sealed in recent years.

- Suggested that Al Grosbold, Director
  Mining Land Reclamation Council
  618-782-0588

  be contacted.

Action Required

EPA - Region III

FILE MEMO

Name Greg Schweer

Date 10/23

Time 3:45

File No. 569.1.1

Subject Coal Mines - Post Mine Drainage Control - in EPA Region III

Persons Contacted:

Name Kathy Hodgekiss

Company EPA Region 3 - Enforcement

Phone 215-597-2945

Name

Company

Phone

Comments:

Hodgekiss knew of no available data but would check around and call B. Kaschak if any relevant data are found.

Action Required

Versar inc.

MEMORANDUM

TO: File

Date: August 16, 1977
475.15-106

FROM: Linda Kay

SUBJECT: State Regulations Pertaining to Coal Mining - ILLINOIS

- -

ILLINOIS
Division of Water Pollution Control, Permit Section
217-782-0610
Mark Bryant

Illinois has established its own regulations for the mining of coal in this state. Permits must be obtained from both the Division of Water Pollution Control and the Department of Mines and Minerals in order to mine. The state has established its own effluent standards which, for some parameters, are more stringent than EPA's BPT standards. Only BPT standards are enforced at present. Mark Bryant is sending Versar a copy of the state's permit conditions.

Sludge disposal does not appear to be much of a problem for Illinois. A sludge build-up has not yet occurred in most treatment facilities. In those cases where a build-up has occurred, mine sediments and sludge are lagooned and evaporated. In some instances, the dried solids are buried. No regulations specifically address sludge disposal, however, state officials consider it a solid mine waste and regulate its disposal under Chapter 4 of the Pollution Control Board Regulations for Mine Related Pollution.

Department of Mines & Minerals
Ernest Ashby 217-782-4970
Bob Robson 217-782-6792

Illinois regulates strip mining and strip mine reclamation. Ernest Ashby is sending Versar a copy of these regulations.

According to both Ernest Ashby and Bob Robson, Illinois has no problem with acid producing coal mines. Apparently all surface mines are required to be designed so as to prevent water from coming in contact with the coal seam. Also, reclamation techniques prevent any problems with run-off.

Bob Robson insisted that deep mines have no drainage problems. He cited two reasons: 1) diminished precipitation in the midwest as compared to the east and 2) the structure of deep mines in Illinois. Deep coal mines in this state are shaft mines running straight down for 250' to 1000'.

MEMO

August 16, 1977

475.15-106

This information contradicts Versar's observations of mining in this state. The Will Scarlet Mine (Peabody Coal) had some of the most acid discharges encountered in the BAT Coal screening sampling.

Environmental Protection Agency
Bob Gates, Field Inspector
618-997-4371

Bob Gates was somewhat more realistic about mine drainage problems in Illinois. He did provide a "partial" list of counties where a potential for acid drainage exists. They include: St. Clair, Monroe, Randolph, Jackson, Johnson, Williamson, Christian, Vermillion, Massac, Pope, Hardin, Saline, Gallatin, Franklin, Madison, Douglas, Bond, Jefferson, Knox, Peoria, Fulton, and Macoupin.

Versar inc.

MEMORANDUM

August 9, 1977

475.15-107

TO: 475.15 File

FROM: Linda Kay LBK

SUBJECT: State Regulations Pertaining to Coal Mining

IOWA

Soil Conservation Department
Division of Mines and Minerals
515-281-5851
Marvin Ross

Iowa does very little to regulate coal mining principally because this industry is so small in this state. Presently there are only 2 underground mines and 7 surface mines in operation. Large deposits of coal, however, underlie this area and officials expect the industry to increase in size in the future with the current emphasis on coal as an energy source.

Iowa does have a surface mine reclamation act that went into effect February 1, 1977. Versar will receive a copy of the act and the accompanying regulations.

Acid mine drainage is not much of a problem in Iowa. Only a couple of mines have acid discharges and, due to relatively low precipitation rates in this area of the country, their discharge volume is minimal. Abandoned strip pits are the largest concern in this respect. During particularly heavy storms, the pits sometimes overflow and discharge acid water into local drainage systems.

Department of Environmental Quality
Division of Water Quality
Joe Cber
515-265-8134

The Division of Water Quality does not make any attempt to monitor drainage from coal mine operations. It does not administer a permit program and it has not established any effluent standards.

All regulation of the coal industry has been delegated to the federal government. The U.S. EPA (Region V) administers the NPDES permit program and enforces BPT effluent standards in this state.

Versar inc.

MEMORANDUM

TO: 475.15 File

Date: August 30, 1977
475.15-114

FROM: Linda Kay

SUBJECT: INDIANA - State Regulations Pertaining to Coal Mining

---

INDIANA

Indiana Stream Pollution Control Board
Water Pollution Control Division
317-633-0751
Jim Ray

Indiana has been approved by EPA to administer the federal NPDES permit program. The state is therefore enforcing BPT effluent standards for the coal mining industry.

According to state water pollution authorities, acid mine drainage is not much of a problem in Indiana. A few abandoned mines are sources of acid water and there are some potentially acid areas along Indiana's southwest border in Vigo, Sullivan, Knox, Gibson, and Posey counties. However, the employment of new mining methods required by the surface mine reclamation act prevents the formation of acid drainage.

The Water Pollution Control Division is not aware of any problems in the industry with sludge disposal and it has not developed regulations which address the topic.

Department of Natural Resources
Division of Reclamation
317-633-6217
Richard McNabb

Indiana has a surface mine reclamation act in effect. Richard McNabb is sending Versar a copy of the act and accompanying regulations.

Surface mining comprises the bulk of the mining industry in this state. There are presently only two active deep mines.

Versar inc.

MEMORANDUM

TO: 475.15 File

Date: August 8, 1977
475.15-99

FROM: Linda Kay

SUBJECT: Ohio - Survey of Coal Mining States Regarding State Regulations Pertaining to Coal Mining.

Ohio

- Department of Natural Resources
  Division of Reclamation
  614-466-4850
  Barbara Merrill

  Ohio regulates strip mining and strip mining reclamation. Division of Reclamation will send Versar a copy of state regulations.

- Division of Mines (Ohio)
  614-466-4240

  This division regulates mine safety only.

- Office of Wastewater Pollution Control
  614-466-2390
  Dave Danford

  Ohio administers EPA's NPDES program and currently has approved 677 permits. Ohio is just beginning to actively monitor mining activities and is currently enforcing BPT standards as they appeared in the Federal Register.[1] In the past, coal mining has been a low priority industry in Ohio. State resources were allocated primarily to the regulation of larger, more dominant industries such as steel and the utilities.

  There appears to be little or no state regulation of the disposal of sludge from treatment facilities. Ohio's permit system requires the optimum operation of treatment facilities, and this requirement permits state officials to demand sludge removal if the sludge build-up becomes a problem in the operation of these plants. Basically, the state's regulation of sludge is handled on a case by case basis. Ohio does have solid waste regulations in force; however they do not address the disposal of sludge from coal operations in particular. Revisions of these regulations to include acid mine drainage sludge are expected in the future.

[1] Ohio has an appeal system that permits the establishment of more stringent effluent standards for certain pristine waters. However, action to establish new standards can only be instigated by citizen complaints.

TO: Division of Water Resources
1200 Greenbrier Street
Charleston, WV 25311

August 6, 1977
475.15-96

FROM: K. Randolph

SUBJECT: State Regulations on Coal Mining: West Virginia

Talked with: Mr. Paul Ware
Water Resources
(304) 348-3614

Date Called: August 4, 1977
10:10 a.m.

West Virginia has a state permit system for regulating coal mine drainage. By and large, this boils down to EPA BPT guidelines. Each permit is handled individually as far as effluent limitations are concerned, but in the majority of cases, the limitations are BPT. There are some exceptions in what were referred to as "sensitive waters". In those cases, the receiving water quality controls the limitations imposed by West Virginia and these are always more stringent than BPT.

West Virginia formulated some "new" water quality standards three years ago, and these are being published this week. Mr. Ware will send us a copy as soon as they are available.

Strip mines are regulated by the Reclamation Division under the Strip Mine Reclamation Act. This act provides some water quality standards that are less stringent than BPT, ($pH > 5.5$, $Fe \leq 10$ ppm). However, Water Resources Division passes on all NPDES permits and they must rule on water quality from strip mines before the mine can get a mining permit. Water Resources, once again, generally imposes BPT standards. Mr. Ware will send us a copy of the Act when he sends the water quality standards.

As for regulation of sludge disposal, this comes under the mining permit, and it is handled on a case by case basis. The mining company must show in their application for a mining permit how any sludge will be disposed of and the Reclamation Act has something to say on this too. West Virginia does not have any formal regulation for sludge disposal. Lagooning, returning to mine, drying and filling may all be acceptable depending on conditions.

I asked if their data on flow and quality of water from coal mines was on a computer or was in a form where the amount of acid drainage in West Virginia could be determined readily. The response was that their management didn't seem to know that computers had been invented. One clerk handles the data and she is two years behind. However, Mr. Ware commented that the AMD problem was serious only in the Monongahela River valley and drainage area. But he had no idea how much water was being treated.

Mr. Ware was very cordial and quite helpful. He said that we were welcome to call anytime.

Versar inc.

MEMORANDUM

August 3, 1977

475.15-102

TO: 475.15 File

FROM: Linda Kay LBK

SUBJECT: State Regulations Pertaining to Coal Mining

MARYLAND

Larry Ramsey
Industrial and Hazardous Wastes, Water Resources Administration
Maryland Department of Natural Resources

The State of Maryland regulates drainage from coal mines. In fact, the Department of Natural Resources maintains a very active program. They have established effluent guidelines, based on in-house studies of the state's particular mining conditions, which are actually more stringent than EPA's BPT guidelines. Maryland monitors turbidity (and therefore TSS), iron, and alkalinity. According to Larry Ramsey, Maryland mines have no problems achieving these standards. Versar will be sent a copy of Maryland's permit conditions.

Maryland has a very effective, centralized enforcement program. While the Bureau of Mines approves mining permits for both deep and surface mines, routine inspection is carried out by the Water Resources Administration. This division is also responsible for the enforcement of the conditions required by other permits necessary for coal mining (Soil Conservation Service permits and water discharge permits). Violations of the conditions of one permit result in the revocation of all permits required for mining. This centralized system is unique among the coal mining states and it appears to encourage a fair and comprehensive regulation of the industry in this state.

Maryland, like other states, does not specifically regulate the handling of acid mine drainage sludge. Solid waste regulations are in effect, however, and disposal of sludge from coal mining - should it occur - must concur with these regulations.

MARYLAND, Con't.

Tony Abar Bureau of Mines 301-269-3382	Robert Creter Water Resources Admin., Cumberland Office 301-777-2134

Maryland has a strip-mining reclamation act, in effect since July 1, 1976. Accompanying regulations have been established and are in the process of revision. Tony Abar is sending Versar a copy of the act and current regulations. Versar will also receive similar regulations pertaining to deep mines.

Sludge disposal does not appear to be a problem in Maryland. The new strip mine reclamation regulations provide for the burial of sludge in strip pits. In most cases, sludge is allowed to remain in the sedimentation ponds and, after the mining operations cease, the liquid portion eventually evaporates. This is especially the case in surface mining operations where sludge build-up is rarely a problem since new ponds are continually being constructed as mining proceeds. Officials expect difficulties with sludge disposal to increase with the opening of more large deep mines within the state.

According to Robert Creter of the Water Resources Administration all coal seams in Maryland are acid producing.

Maryland Effluent Standards for Coal Mines

pH 6.0 - 9.0

Alkalinity must exceed acidity

*Turbidity 100 Jackson Campbell units

TSS 35 mg/l (average) 45 mg/l (maximum)

Total iron 4.0 mg/l (maximum)

*Turbidity has been correlated with total suspended solids for ease of measurement in the field.

Kentucky

FILE MEMO

Name Greg Schweer
Date Nov. 12, 1980
Time 2:15 p.m.
File No. 569.1.1
Subject Coal Mines - Post Mine Drainage Control - State of Kentucky

Persons Contacted:

Name	Joey Roberts	Name	
Company	Kentucky Dept. of Natural Resources & Environmental Protection Div. of Standards and Specifications	Company	
Phone	502-564-2377	Phone	

Comments:

Since 1978, water quality monitoring of discharge from active mines has been required under the NPDES program. However, compliance in reporting has not been good and data has not been compiled into any readily accessible form.

The State of Kentucky has discouraged the practice of underground mine sealing based on expected failure of seals.

Action Required

FILE MEMO

Name Greg Schweer

Date 11/13/80

Time 2:00 p.m.

File No. 569.1.1

Subject Coal Mines - Post Mine Drainage Control
- State of Kentucky

Persons Contacted:

Name	David Rosenbaum	Name	
Company	Kentucky Dept. of Natural Resources and Environmental Protection Division of Abandoned Lands	Company	
Phone	502-564-2141	Phone	

Comments:

Mr. Rosenbaum heads this newly formed Division of Abandoned Lands. This division will be addressing acid mine drainage problems and developing abatement plans. To his knowledge, there has been very little sealing of abandoned mines in Kentucky in the past and there is little if any monitoring data on mine drainage. His division will be undertaking an inventory of abandoned mines in the state within three weeks.

At present, OSM is constructing an emergency seal on a mine in Knott county. The state is designing cover seals for three mines in western Kentucky.

Action Required

FILE MEMO

Name	Greg Schweer	**Date**	11/13/80
Time	2:15	**File No.**	569.1.1

Subject Coal Mines - Post Mine Drainage Control
- State of Maryland

Persons Contacted:

Name	Anthony Abar	**Name**	
Company	Maryland Dept. of Natural Resources Bureau of Mines	**Company**	
Phone	301-689-4136	**Phone**	

Comments:

The only potentially relevant data Maryland has is:

1. Preliminary monitoring data for the Lostland Run daylighting project.
   - data will be presented in a draft report soon by
     Ackenaeil and Associates
     Pittsburgh, PA
     (Peter Campion 412-531-2470)
   - pre-, during, and post-data are available. Post data, at present, is being collected. Three months worth of data are available and data will be collected for another 9 months.

Action Required

2. Maryland conducted a one-year monitoring study of acid mine drainage in the early 1970s. Data was collected in the Castleman, Cherry Creek, and Georges Creek watersheds. The data is quite extensive and identifies individual mines and associated water quality. Some of the identified mines had been sealed in the past.

The State of Maryland has not conducted any mine sealing programs; considers treatment of AMD to be more feasible and reliable.

West Virginia

FILE MEMO

Name Greg Schweer

Date 11/12/80

Time 3:15

File No. 569.1.1

Subject Coal Mines - Post Mine Drainage Control - State of West Virginia

Persons Contacted:

Name	Paul Ware	Name	
Company	W.Va. Dept. of Natural Resources Division of Water Resources	Company	
Phone	304-348-3614	Phone	

Comments:

No program is underway in W. Va. to seal abandoned mines. However, Mr. Ware stated that he is aware of several dozen mines which have been sealed and for which pre-sealing water quality data probably could be compiled and made accessible to EPA. Little if any post-sealing water quality data is expected to be available.

Action Required

West Virginia

FILE MEMO

Name Greg Schweer

Date 11/12/80

Time 3:30

File No. 569.1.1

Subject Coal Mines - Post Mine Drainage Control
State of West Virginia

Persons Contacted:

Name Dave Kessler

Company W.Va. Dept. of Mines (Hdqtrs.)

Phone 304-348-2061

Name

Company

Phone

Comments:

Mr. Kessler can provide a computerized list of abandoned mines for which mine maps are available. In regards to sealed mines and sealing techniques, he suggested that the five regional divisions be contacted:

Northern Division - Grant King - 292-5642
Oak Hill Division - Frank Legg - 469-2222
Vivian Division - Ed Jarvis - 585-7013
Logan Division - Mr. Cook - 239-2326
Kanawha Division - Jim Gillespie - 442-2823

Action Required

REFERENCE 2

HYDROTECHNIC TRIP REPORT

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Trip Report - Pennsylvania Department of Environmental Resources

Pennsylvania D.E.R.
Fulton Building
3rd and Locust Street
Harrisburg, PA

Prepared by: Victoria Lickers - Hydrotechnic Corp.

Date of Trip: October 9, 1980

Purpose of Trip: Obtain data on inactive coal mines and post-mining discharges

Contacts:		
	Kathy Seiber	(717) 787-9646
	Dix Hoffman	(717) 787-8184
	Ernest Giovannitti	

Results:

Seven facilities, representing cases of successfully sealed mines with no discharge problems, and sealed mines where post-mining discharges have occurred, were selected for review by DER. These files had been pulled:

1. Barnes & Tucker Co.
   567M035 and 567M028 (same mine - two permits)
2. Margaret #7 Mine
   366M006
3. Wildwood Mine
   466M011
4. JVN Mine
   367M034
5. Carrolltown No. 2 Mine
   566M006
6. North Camp No. 1 Mine
   266M032

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Barnes & Tucker, Margaret #7 Mine, and Wildwood Mine have all had problems with post-mining discharges. The remaining three facilities fall into the "sealed, no discharge" category.

Data was Xeroxed and is now on file in Hydrotechnic's office for all facilities except the JVN Mine and the Barnes & Tucker facility. The remaining data is to be copied by DER personnel and forwarded to Hydrotechnic.

It was learned (from D. Hoffman) that the number of inactive mines in Pennsylvania, for which the operators are responsible, probably falls within the range of 300-500. Those facilities in the "sealed, no discharge" category are inspected about twice a year (after the first 5-year period) by DER personnel. Due to limited manpower, only the portals are checked for discharge. There is no groundwater monitoring or engineering analysis performed.

Mines with discharge problems would be monitoring more closely, depending upon the circumstances.

Based upon his understanding of the information that EPA was after, Hoffman did not seem to think that obtaining data for more than the selected 7 facilities was necessary. He also stated that for someone to piece together the background of a particular facility from the files could be difficult and time-consuming.

Since there was a great deal of data (much of it legal correspondence) concerning the Barnes & Tucker facility, the need to Xerox and/or use all of it was questioned. E. Giovannitti was consulted as to the possibility of someone familiar with the case preparing a short "history" of the problem, actions taken, etc. He responded that it would be difficult, and that he didn't know who would be qualified to do it. He suggested that if EPA were to get in touch with him regarding a specific aspect of the problem, he may be able to help.

Giovannitti also noted that he thought the EPA was stressing the wrong aspect of the post-mining discharge problem. He felt that more attention should be paid to those mines which have been successfully sealed and to the sealing techniques employed, rather than to treating the post-mining discharges that occur at some of the inactive mines. As he pointed out, treating the discharge from an active or an inactive mine is essentially the same.

REFERENCE 3

RESULTS OF 1980 LITERATURE SEARCH

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U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-272 373

LONG-TERM ENVIRONMENTAL EFFECTIVENESS OF CLOSE DOWN PROCEDURES EASTERN UNDERGROUND COAL MINES

HRB-Singer, Inc., State College, Pa.

Prepared for

INDUSTRIAL ENVIRONMENTAL RESEARCH LAB - CINCINNATI, OHIO

Aug 77

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Report No.: EPA-600/7-77-083

Title and Subtitle: Long-Term Environmental Effectiveness of
Close Down Procedures - Eastern Underground Coal Mines

Authors: M. F. Bucek and J. L. Emel

Performing Organization Name and Address:

HRB-Singer, Inc.
P. O. Box 60
Science Park, State College, PA 16801

Sponsoring Agency Name and Address:

Industrial Environmental Research Lab. - Cin., OH
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

Abstact:

The objective of the research project was to prepare an up-to-date document on deep mine closures that have been or are planned to be implemented in the eastern coal mining regions. The project was also to provide an initial overview of the effectiveness of the closure methods and the factors to which their effectiveness can be attributed. The effectiveness was evaluated in terms of a closure effect on mine drainage quality and quantity.

The trend analyses of the pollutant concentrations and outputs for the pre- and post-closure periods show that the closures for more than half of the sites reversed or reduced increasing pollutant trends, augmented the already decreasing trends, and reduced variability in fluctuations of the water quality. The effectiveness of the mine closures with respect to the mine effluent quality by comparison with the preliminary mine effluent guidelines was observed to be usually less than 50 percent effective. The degree of closure effectiveness with respect to the mine water quality improvement was found to be predominantly determined by the physical and mining framework to the sites and less by the closure technology.

EPA-600/7-77-090
August 1977

ELKINS MINE DRAINAGE
POLLUTION CONTROL
DEMONSTRATION PROJECT

by

Resource Extraction and Handling Division
Industrial Environmental Research Laboratory
Cincinnati, Ohio 45268

Edited by

PEDCo Environmental, Inc.
Cincinnati, Ohio 45246

Contract No. 68-02-1321

Project Officer

Ronald D. Hill

INDUSTRIAL ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO 45268

ABSTRACT

Underground and surface coal mining operations have resulted in degradation of the environment. Past mining operations continue to pollute streams with acid, sediment, and heavy metal laden waters. Land disturbed during mining lies deluged, and useless. In 1964 several Federal agencies in cooperation with the State of West Virginia initiated a project to demonstrate methods to control the pollution from abandoned underground and surface mines in the Roaring Creek-Grassy Run watersheds near Elkins, West Virginia.

The Roaring Creek-Grassy Run watersheds contained 400 hectares of disturbed land, 1200 hectares of underground mine workings and discharged over 11 metric tons per day of acidity to the Tygart Valley River. The reclamation project was to demonstrate the effectiveness of mine seals, water diversion from underground workings, burial of acid-producing spoils and refuse, surface mine reclamation, and surface mine revegetation. Following a termination order in 1967, major efforts were directed away from the completion of the mine sealings and toward surface mining reclamation and revegetation. In July 1968 the reclamation work was completed with the reclamation and revegetation of 284 hectares of disturbed land and the construction of 101 mine seals.

Results of an extensive monitoring program revealed that some reduction in acidity load (as high as 20 percent during 1968 and 1969), and little if any in iron and sulfate loads and flow have occurred in Grassy Run. Roaring Creek had an insignificant change in flow as a result of water diversion, and a decrease of 5 to 16 percent in acidity and sulfate load. Biological recovery in both streams has been nonexistent except in some smaller subwatersheds. Good vegetative cover has been established on almost all of the disturbed areas. Legumes dominate in most areas after eight years. Tree survival and growth has been good.

Average reclamation costs (at 1967 prices) were as follows: surface mine reclamation - $4,150/hectare, seal construction - $4,140/seal, and revegetation - $620/hectare.

EPA-600/3-80-070
July 1980

ENVIRONMENTAL EFFECTS OF WESTERN COAL SURFACE MINING
PART VIII - FISH DISTRIBUTION IN TROUT CREEK, COLORADO, 1975-1976

by

John P. Goettl, Jr. and Jerry W. Edde

Colorado Division of Wildlife
Fisheries Research Center
Fort Collins, Colorado 80522

Grant No. R803950

Project Officer

Donald I. Mount
Environmental Research Laboratory-Duluth
Duluth, Minnesota 55804

ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
DULUTH, MINNESOTA 55804

ABSTRACT

A study was conducted on Trout Creek in northwestern Colorado during 1975-1976 to assess the effects of drainage from an adjacent surface coal mine on the distribution of fishes in the creek, and to relate their distribution to physical and chemical variables. A second objective was to determine the possible toxicity of surface coal mine drainage water on fish stocked in ponds receiving surface and groundwater run-off from the mine.

Results did not indicate any direct effects of mine drainage water on the distribution of fishes in Trout Creek, although possible effects may have been masked by elevation, stream flow, streambed alterations, and agricultural irrigation return flows. Brook trout (*Salvelinus fontinalis*) was the dominant salmonid species in the upper reaches of the creek; rainbow trout (*Salmo gairdneri*) and brown trout (*S. trutta*) were found only in the region of the mine. Mottled sculpin (*Cottus bairdi*) and speckled dace (*Rhinichthys osculus*) were the most common fishes found throughout and at all but the uppermost reaches, respectively.

Rainbow trout stocked in mine seepage water ponds for a year evidenced high survival rates over an eight-month period during the winter, but fared poorly during the ensuing summer months, this latter most probably because of extremely high water temperatures. There was no apparent evidence of toxicity to the fish from contaminants in the mine pond water.

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-264 936

Water Pollution Caused by Inactive Ore and Mineral Mines - A National Assessment

Toups Corp, Santa Ana, Calif

Prepared for

Industrial Environmental Research Lab -Cincinnati, Ohio Resource Extraction and Handling Div

Dec 76

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.
EPA-600/2-76-298

2.

3. RECIPIENT'S ACCESSION NO.

4. TITLE AND SUBTITLE
WATER POLLUTION CAUSED BY INACTIVE ORE
AND MINERAL MINES - A National Assessment

5. REPORT DATE
December 1976 issuing date

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Harry W. Martin
William R. Mills, Jr.

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Toups Corporation
1010 N. Main Street
Santa Ana, CA 92711

10. PROGRAM ELEMENT NO.
1BB040

11. CONTRACT/GRANT NO.
68-03-2212

12. SPONSORING AGENCY NAME AND ADDRESS
Industrial Environmental Research Laboratory - Cin., OH
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

13. TYPE OF REPORT AND PERIOD COVERED
Final

14. SPONSORING AGENCY CODE
EPA/600/12

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The report identifies the scope and magnitude of water pollution from inactive ore and mineral mines. Data collected from Federal, State, and local agencies indicates water pollution from acids, heavy metals, and sedimentation occurs at over 100 locations and affects over 1200 kilometres of streams and rivers. The metal mining industry was shown to be the principal source of this pollution.

Descriptions of the mineral industry are presented, including a summary of economic geology, production methods, and historic mineral production methods, and historic mineral production. The mechanisms of formation, transporation, and removals of pollutants are detailed.

Annual pollutant loading rates for acid and metals from inactive mines are given and a method provided to determine the extent of mine-related sedimentation in Western watersheds. State-by-state summaries of mine related pollution are presented. An assessment of current water pollution abatement procedures used for inactive mines is given and research and development programs for necessary improvements are recommended.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Water Quality Water Pollution Metalliferous Minerals Metalliferous Mineral Deposits Mining Waste Disposal Mine Surveys Assessments	Ore and Mineral Mines Metal Mining Acid Mine Drainage Heavy Metals Pollution Control Tech. R and D Programs	13/B 08/I

18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC	19. SECURITY CLASS *(This Report)* UNCLASSIFIED	21. NO. OF PAGES
	20. SECURITY CLASS *(This page)* UNCLASSIFIED	22. PRICE PC [illegible] MF A01

EPA Form 2220-1 (9-73)

*USGPO: 1977 — 757-056/5481 Region 5-11

EPA-430/9-73-011

October 1973

PROCESSES, PROCEDURES, AND METHODS TO CONTROL POLLUTION FROM MINING ACTIVITIES

U. S. Environmental Protection Agency
Washington, D. C. 20460

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $3.40

EPA-440/9-75-007

INACTIVE & ABANDONED UNDERGROUND MINES

Water Pollution Prevention & Control

U.S. ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

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ABSTRACT

Underground mining operations across the United States produce a number of environmental problems. The foremost of these environmental concerns is acid discharges from inactive and abandoned underground mines that deteriorate streams, lakes and impoundments. Waters affected by mine drainage are altered both chemically and physically.

This report discusses in Part I the chemistry and geographic extent of mine drainage pollution in the United States from inactive and abandoned underground mines; underground mining methods; and the classification of mine drainage control techniques. Control technology was developed mainly in the coal fields of the Eastern United States and may not be always applicable to other regions and other mineral mining.

Available at-source mine drainage pollution prevention and control techniques are described and evaluated in Part II of the report and consist of five major categories: (1) Water Infiltration Control; (2) Mine Sealing; (3) Mining Techniques; (4) Water Handling; and (5) Discharge Quality Control. This existing technology is related to appropriate cost data and practical implementation by means of examples.

A summary of the mineral commodities mined in the United States follows Part II and relates to type, locale and environmental effects.

A list of minerals, mineral formulas, glossary and extensive bibliography are included to add to the usefulness of this report.

REFERENCE 4

FINAL SURVEY REVIEW TELEPHONE MEMO'S

RECORD OF CONVERSATION

7/7/82 3:30PM

TELCON MEMO

Contacted: Ted Ifft at 343-7887

Organization: Federal Reclamation Program, OSM

Caller: James Spatarella, EPA (WH-553)

Subject: Coal Mining Reclamation

Discussion: The program actually started sealing and reclamation projects in FY78. That year the projects were only to prevent endangering lives at abandoned mines. The majority of our projects started in FY80 and FY81 (Note - There have been up to 10 projects at one mine) with 131 shaft projects and 199 other projects completed or under contract. There have been no known failures at mines with completed sealing projects.

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RECORD OF CONVERSATION

7/7/82 3PM

TELCON MEMO

Contacted: Charles Crawford at 343-7921

Organization: Abandoned Mine Lands Program, OSM

Subject: Coal Mining Reclamation

Caller: James Spatarella, EPA (WH-553)

Discussion: The program is just moving into full swing with many states waiting for our funding. One project in W. VA has been recently completed (Feb. 82) with 1,100 projects anticipated likely.

Another source of information might be the Federal Reclamation Program, OSM.

RECORD OF CONVERSATION

7/16/82 2:30PM

TELCON MEMO

Contacted: Dix Hoffman at (717) 787-8183

Organization: Pennsylvania Department of Environmental Resources

Caller: James Spatarella, EPA (WH-553)

Subject: Coal Mining Reclamation

Discussion: This call was identified as a follow-up to the Hydrotechnic trip of October 1980 which he remembered. He explained that little new progress has been made in quantifing the extent of the problem. The data given to Hydrotechnic was the results of the last attempt on defining the problem and was based on permits from 1965-1975 that were found to be inactive in 1980. This method estimated ≈ 1,000 closed mines in the state but no data on the number of closed mines causing water quality problems.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

AUG 25 1982

MEMORANDUM

SUBJECT: Investigation of Post-Mining Discharges After SMCRA Bond Release

FROM: James J. Spatarella, Environmental Engineer
Monitoring and Data Support Division (WH-553)

TO: Bill Telliard, Chief
Energy and Mining Branch
Effluent Guidelines Division (WH-552)

THRU: Alec McBride, Chief
Water Quality Branch
Monitoring and Data Support Division

The attached memo is forwarded for inclusion in reference (4) of the subject issue paper. The memo documents our last attempt to update the 1980 telephone survey, and again shows the lack of available data from state agencies. The results of this survey are consistent with the issue paper.

cc: Rod Frederick (WH-553)
Allison Phillips (WH-552)
Joe Freedman (A-131)
Chip Lester (WH-586)

Versar INC.

M E M O R A N D U M

TO: Jim Spatarella

cc: B. Maestri
M. Neely

FROM: Justine Alchowiak JA

DATE: August 25, 1982

SUBJECT: Type and Availability of Data Concerning the Long-Term Effectiveness of Underground Coal Mine Sealing Procedures

569TM-232

A telephone survey was conducted between August 19 and 23, 1982 by Versar personnel to determine the type and availability of monitoring data and other relevant data that will enable MDSD to assess the long-term effectiveness of underground coal mine sealing procedures. The scope of this survey was limited to obtaining information from the state mining and/or environmental officials in eight coal producing states (Pennsylvania, Tennessee, Maryland, Alabama, Illinois, West Virginia, Kentucky and Virginia). A similar survey was conducted by Versar in October 1980. The results of the limited number of interviews conducted indicate that since 1980 little additional data pertinent to this survey are available. The available data are summarized below.

Pennsylvania - Approximately 40 to 50 mines have been sealed. These data were previously available to EPA. Any available monitoring data are available in the HRB-Singer Study (also mentioned in the October 1980 survey) and in the files maintained by the state's Dept. of Environmental Resources, Abandoned Mine Area Restoration Division.

Maryland - One mine sealed recently (March 1980). Water quality monitoring has been done in cooperation with the U.S. Bureau of Mines.

Alabama - Three mines have been sealed, however, they have not been sealed in accordance with SMCRA regulations. Water quality monitoring data are available for two mines which discharge into the Main Creek Watershed. Fish kills have occurred in the area. There is a court suit pending against the mine owners.

Tennessee - No new data available.

Illinois - Approximately 40 to 50 mines have been sealed since 1977. These mines have not been sealed in accordance with SMCRA regulation. No water quality data available at this time. A water quality program is expected to start in 1983.

West Virginia - Limited water quality data may be available.

Kentucky - Limited water quality data may be available.

Virginia - Limited water quality data may be available.

Attached to this memorandum are copies of the file memos for each telephone interview conducted. Please contact me if you have any questions.

IUS 5183

Pennsylvania

FILE MEMO

Name Pat Wood

Date 8/19/82

Time

File No. 569.1.1

Subject Coal Mines - Confirmation of 1980 info for Post Mine Drainage Control - State of PA

Persons Contacted:

Name	Dave Hogeman	**Name**	
Company	Abandoned Mine Area Restoration Div., Dept. of Environ. Res.	**Company**	
Phone	717-787-7668	**Phone**	

Comments:

8/19 will return call.

8/20/82 Preconstruction H_2O quality data
Post construction monitoring data for seals and H_2O drainage
Approx. 40-50 mines have been sealed. HRB - Singer study covers mine techniques used. Any obtainable data plus HRB Singer study are contained in the Star files and should be requested through Bud Fredrick.

Abandoned Mine Area Restoration Div.
Dept. of Environmental Resources

Action Required

FILE MEMO

Name	Pat Wood	**Date**	8/19/82
Time		**File No.**	569.1.1

Subject Confirmation of 1980 info concerning Post Mine Drainage control in Pennsylvania

Persons Contacted:

Name	Evan Schuster	**Name**	
Company	Bureau of Water Quality Mgmt	**Company**	
Phone	717-787-8184	**Phone**	

Comments:

Mr. Schuster will be in the office on Monday and will return call.

Mr. Schuster says situation in Pa. is the same. However, approx. 30 mines are sealed now since 1976. All H_2O monitoring data and inspection reports are in the files. The Bureau is now (very recent) working with OSM and frequent monitoring is expected to follow in the next year. Is not aware of any sealing, environmental or H_2O quality problems. Due to lack of funds, the Bureau has not kept a very good tracking record.

Action Required

FILE MEMO

Name Pat Wood

Date 8/19/82

Time

File No. 569.1.1

Subject Mine sealing and Drainage Control. New info and confirmation of 1980 info.

State of Maryland

Persons Contacted:

Name	Jeff McCombs	Name	
Company	Bureau of Mines in Maryland	Company	
Phone	301-689-4136	Phone	

Comments:

8/20/82 Mr. McCombs is in the field. Will return call later.

8/20/82 Bear Creek mine is the only recent mine sealed. Completed March 1980. Monitoring has been done in cooperation with the U.S. Bureau of Mines. All data has been handled by (see below).

U.S. Bureau of Mines
Lester Adams @ 412-675-4331

Action Required

FILE MEMO

Name Pat Wood

Date 8/20/82

Time

File No. 569.1.1

Subject Mine sealing techniques and its effectiveness; confirmation of 1980 info.

State of Alabama

Persons Contacted:

Name	Bob Weller	Name	
Company	Alabama Land Reclamations	Company	
Phone	205-832-6753	Phone	

Comments:

8/20/82 Will return call.

8/20/82 Filling with spoils/clay/dirt/ and sealed with concrete cap. Sealed for safety due to growth of housing population in the immediate area.

Action Required

EPA Region IV

FILE MEMO

Name Pat Wood

Date 8/20/82

Time

File No. 569.1.1

Subject Post Mine Drainage Control in EPA Region IV

Persons Contacted:

Name Mr. Bill Taylor	**Name** Ken McDowell
Company EPA - Atlanta	**Company** Alabama H_2O Improvement Commission
Phone 404-881-4727	**Phone** 205-277-3630

Comments:

8/23 Referred to Ken McDowell
205-277-3630 Alabama

8/23 Underground - not known. Referred me to Alabama Underground Mine Authority - 205-221-4130.

Mr. McDowell is currently involved in project concerning discharge from two abandoned mines. One mine has low Ph and other high Ph and contain aluminum. Interaction has caused an Al precipitation believed to be $AlOH_3$ causing flocculation in the creek bed. This, in turn, is causing fish kill. The mines claim the same watershed. One empties directly into the main creek and the other into a tributary of the main creek. Data has been gathered for 1 1/2 years and is available to EPA. There is to be a court suit against the mine owners Aug/Sept.

Action Required

Tennessee

FILE MEMO

Name Pat Wood

Date 8/19/82

Time

File No. 569.1.1

Subject Mine Sealing - New info since 10/80 and confirming old info.
State of Tennessee

Persons Contacted:

Name	Cliff Bole	Name	
Company	Tenn. State Water Quality Control Board	Company	
Phone	615-741-6636	Phone	

Comments:

No new changes that he is aware of but referred me to:

1. 615-546-4783
   Director - Arthur Hope
   Div. of Surface & Mines
   Dept. of Conservation

2. MESA (Mining Enforcement Safety Assoc.)
   Max Condra (615) 942-3389
   Frank Durbin (615) 424-9439

Action Required

8/23 Frank Durbin - No longer with MESA
Max Condra will return call on Thursday 8/26/82.

Illinois

FILE MEMO

Name Pat Wood

Date 8/19/82

Time

File No. 569.1.1

Subject Post Mine Drainage Control - Confirmation of Oct. 1980 info. State of Illinois

Persons Contacted:

Name	Sue Massie, Director	**Name**	Steve Jenkusky for Sue Massie
Company	Mining Land Reclamation Council	**Company**	
Phone	217-782-0588	**Phone**	

Comments:

8/19 Will return call.

8/23 Will return call.

8/23 Mr. Jenkusky informed me that the state of Illinois has sealed 40-50 mine openings since 1977 Act. The goal was to protect humans rather than other reasons for sealing. Sealing techniques used are capping and filling for shaft mines. However, capping has been found to be ineffective somewhat due to settling of the concrete which causes cracks and holes. If surface area is on a drift, the opening is filled and then covered with a concrete cap. For sloped surfaces, filling has been found to be effective. To date, there is one drift opening with drainage. Consequently, a drain pipe was installed because drainage was not acidic. Monitoring has not been done but will start next year. For technical info, call Mr. Jenkusky. He is also interested in any documents available in our files.

Action Required

FILE MEMO

Name Pat Wood

Date 8/20/82

Time

File No. 569.1.1

Subject Mine sealing and drainage control
State of West Virginia

Persons Contacted:

Name	Jessie Cromer	Name	
Company	W.Va. Dept. Natural Resources	Company	
Phone	304-636-1767	Phone	

Comments:

Dry seal - plug up to maintain H_2O
Wet seal - pipe to outside to drain H_2O

Regulated only in last two years.

Abandoned mines are monitored occassionally by Abandoned Mine Division. Drain to high quality stream is the only time monitoring is done by DNR.

Action Required Dept. of Mines in Charleston, W.Va. may have more info. 348-2051.

FILE MEMO

Name Pat Wood

Date 8/20/82

Time

File No. 569.1.1

Subject Mine Sealing & Drainage Control

State of W. Va.

Persons Contacted:

Name Mr. Jordan, Dept. of Mines

Company Charleston, W.Va.

Phone 304-348-2051

Name

Company

Phone

Comments:

Controls Sealing of Mines

Sealing Types:

1. Cinderblock with pipe
2. Back seal - 20 ft. long pipe (backfilled) 15 ft.

Shaft mines = cap off or fill completely with dirt or spoil.

No failures to his knowledge.

Action Required

Approx. more than 1000 openings sealed
(not mines) may be 12-15 openings/mine.
Reclamation Bond - reclamation on outside.

1. Tear down unused surface structure.
2. Seal mine openings.

All monitoring of H_2O quality is done by DNR. Request data availability from DNR.

Kentucky

FILE MEMO

Name Pat Wood

Date 8/20/82

Time

File No. 569.1.1

Subject Mine sealing techniques, effectiveness and monitoring; confirmation of 1980 info.

State of Kentucky

Persons Contacted:

Name Nancy Toombs	Name Mr. Turner
Company Kentucky, Dept. of Mines and Minerals	Company
Phone 606-254-0367	Phone 437-9616

Comments:

8/20/82 Will return call

8/20/82 MSHA

Suggested I call local MSHA (233-2677 - 437-9616)

8/23 Mr. Clyde Turner

Use two techniques:

1. fill openings with seal (earth)
2. concrete stopper at the entrance

Action Required

For shaft mines, soil filling techniques is normally used. Slope - soil filling and the concrete slab for applying.

Kentucky is divided into three mining districts for MSHA work. Therefore, Mr. Turner is not aware of # of mines sealed. Office of Surface Mines do H_2O quality data and State H_2O Control Board does QC work.

FILE MEMO

Name Pat Wood

Date 8/20/82

Time

File No. 569.1.1

Subject Coal Mines - Post Drainage Control
State of Virginia

Persons Contacted:

Name	Mr. Louis Wheatley	Name	
Company	Va. Dept. of Labor & Industry Division of Mines & Quarries	Company	
Phone	703 - 523-0335	Phone	

Comments:

Mr. Wheatley is not aware of any new changes in the state program. He thinks that the Division of Mine, Land, Reclamation section monitors H_2O from mine drainage. Controls mines with area greater than 2 acres.

Refer to 703-523-2925, Div. of Mine, Land, Reclamation.

Action Required

FILE MEMO

Name Pat Wood

Date 8/20/82

Time

File No. 569.1.1

Subject Post Mine Drainage Control in EPA Region III

Persons Contacted:

Name	Kathy Hodgekiss	Name	
Company	EPA Region III - Enforcement	Company	
Phone	215-597-9023	Phone	

Comments:

8/20 - no answer

8/23 - no answer

8/23 - Kathy will return call. Will be on Travel thru Tuesday 8/24/82.

Action Required

REFERENCE 5

FILE HISTORIES OF SIX CLOSED PENN. COAL MINES

Detailed files of the following mines are contained in the rulemaking record for this regulation:

1. Barnes & Tucker Co.
   567M035 and 567M028 (same mine - two permits)
2. Margaret 17 Mine
   366M006
3. Wildwood Mine
   466M011
4. JVN Mine
   367M034
5. Carrolltown No. 2 Mine
   566M006
6. North Camp No. 1 Mine
   266M032

The record is available in EPA's Public Information Reference Unit, Room 2004, 401 M Street, S.W., Washington, D.C. 20460.

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REFERENCE 6

1982 LITERATURE SEARCH REPORT

(PRINTOUT)

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18/5/2

1257440 ID NO. E18205037440

SEALING AN UNDERGROUND DEEP MINE IN PENNSYLVANIA.

Beck, Laurance A.
Pa Mines Corp., Ebensburg, Pa.
Segg Pgp - AM Min Congr Coal Conv, St. Louis, Mo, Mag 10-13 1981 Publ bg Am Min Congr, Washington, DC, USA, 1981 17 p

This paper describes the methods used at the Oneida Mine by Pennsylvania Mines Corporation to meet sealing regulations in Pennsylvania. 7 refs.

DESCRIPTORS: (*COAL MINES AND MINING, *Pennsylvania),
CARD ALERT: 503

18/5/55

827159 ID NO. - E1780427159

PREDICTION OF THE DRAINAGE CONTROL BY MINE SEALING $EM DASH$ 2. STUDIES ON THE TECHNIQUE TO PREVENT THE MINING POLLUTION AT A CLOSED MINE.

Oks, Yukitoshi; Terada, Makoto; Kuroda, Kazuo; Komukaemori, Kazuo; Nakano, Koji; Katasiri, Makio; Hakari, Nobuo
J Min Metall Inst Jpn v 93 n 1075 Sep 1977 p 603-608 CODEN: NIKKA9

AT the Horobetsu Sulphur Mine, a closed mine in Hokkaido, Japan, strongly acid mine water continues to flow out from the underground at the rate of 4-7 cu m/min. The treatment of acid mine water has been carried out by the lime-neutralization method since the closing of the mine. Recently, however, the lack of room for dumping the sludge produced in waste water treatment has become an urgent problem. Therefore, the authors have considered the sealing of the mine to reduce drainage. This article describes the hydrological curves conducted for this purpose, and the prediction of the effect of sealing on mine drainage. 4 refs. In Japanese with English abstract.

DESCRIPTORS: (*MINES AND MINING, *Drainage), (SULFUR DEPOSITS, Japan), (WATER TREATMENT, INDUSTRIAL, Japan),
IDENTIFIERS: SULFUR MINES AND MINING
CARD ALERT: 502, 505, 452, 445

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18/5/15

133354 W79-03247
Inactive and Abandoned Underground Mines. Water Pollution Prevention and Control.
Scott, R. L.; Hays, R. M.
Baker (Michael), Jr., Inc., Beaver, PA.
Available from the National Technical Information Service, Springfield, VA 22161
as PB-258 263, Price Codes: A14 in paper copy, A01 in microfiche, Report No. EPA-440/9-75-007,
June 1975. 293 p, 54 fig, 14 tab, 132 ref. 68-01-2907.
Journal Announcement: SWRA1207

The chemistry and geographic extent of mine drainage pollution in the U.S. from inactive and abandoned underground mines is discussed; underground mining methods are surveyed. Mine drainage control technology, largely developed in eastern U.S. coal fields and not always applicable to other regions and other mineral mining, are classified into two main categories: (1) at-source and (2) treatment. At-source mine drainage pollution prevention and control techniques are evaluated and described according to the following classifications: water infiltration control; mine sealing; mining techniques; water handling; and discharge quality control. Appropriate cost data is related, examples technique implementation are given. A summary of the mineral commodities mined in the U.S. includes location and the environmental effects associated with mining them. An extensive bibliography is provided. (Davison-IPA).

Descriptors: *Water pollution control; *Mine drainage; *Underground structures; *Acid mine water; water quality control; Pollution abatement; Water pollution sources; Costs; Mineral industry; Mine wastes; Mine water; Metals; Nonmetals; Coal; Thorium; Uranium.

Section Heading Codes: 50 (Water Quality Management and Protection - Water Quality Control); 50 (Water Quality Management and Protection - Waste Treatment Processes).